B. Loxe

Nov. 14/78

0.65

PRACTICAL VENTILATION

AS APPLIED TO

PUBLIC, DOMESTIC, AND AGRICULTURAL STRUCTURES

BEING AN ELUCIDATION OF PLANS AND SUGGESTIONS, OF EASY APPLICATION, FOR VENTILATING EVERY SPECIES OF ARCHITECTURAL STRUCTURE

WITH

REMARKS ON HEATING, CONSTRUCTION OF FIREPLACES, CURE OF SMOKY CHIMNEYS; AND AN APPENDIX ON THE VENTILATION OF SHIPS, STEAMBOATS, AND RAILWAY CARRIAGES

BY

ROBERT SCOTT BURN

ENGINEER

WILLIAM BLACKWOOD AND SONS
EDINBURGH AND LONDON
MDCCCL

PRINTED BY WILLIAM BLACKWOOD AND SONS, EDINBURGH.

CONTENTS

INTRODUCTION

THOUGH many years have elapsed since men of science first demonstrated the fact that the inhalation of impure air, which had been previously expelled from the lungs, exerted a very deleterious effect upon the party subject to its influence; still it has been only within a very short period that the importance of Ventilation, not only as a means of withdrawing foul from, but of securing a large supply of fresh air to, the interiors of our houses, has been fully recognised: and its due value assigned to the fact that such supply is eminently conducive to the right performance of the mental, as well as of the physical functions of the human frame. For a considerable period, however, after the necessity of Ventilation had become fully established, it was considered more as a subject interesting in the study, than as a means of actually removing the evils which it proposed to obviate: in fact, it was more treated of theoretically, than attempted to be reduced to practice. By the appalling disclosures given in the admirable Reports of the Parliamentary Commissioners, appointed to examine into what in the popular language of the day is known as the "sanitary condition" of our large towns—and by the efforts of private individuals, the attention of the public has been at last forcibly arrested to the subject. Thus, as in all similar cases, practically scientific men were encouraged to give their attention to the subject: plans were proposed, and in some cases carried into effect; and the Legislature by its exertions gave a mighty impetus to the movement. Experience gave rise to many improvements; some of our first men of science promulgated their ideas on the subject; philanthropists began to interest themselves in the improvement of the dwelling-houses of the poor; the art was more and more divested of its intricacy and apparent difficulty; the simple laws of nature regulating the motions of the atmosphere were taken advantage of, and rendered subservient to simple modes: and the result of all this has been the establishing of the fact, that not only is the ventilation of every structure which man inhabits and uses practicable, but that it can in every case be effected easily and cheaply.

The Author of this Treatise has for many years devoted his attention almost exclusively to the subject of Ventilation, and has studied, with a view to their introduction, the various plans promulgated during the last few years. Convinced of the great importance of the subject, and being of opinion that a Work is much wanted at the present time, in which it is presented in an available point of view, elucidating it in simple explanations free from technicalities—he has been induced to prepare the following Remarks for publication. In throwing together the results of his own experience, and in explaining the methods of others, he has endeavoured to give those only which can be termed "eminently practical;" invariably preferring to give such, rather than theoretical details not necessary for the understanding of the system:—his object being to present a Work which can be referred to for useful purposes, and which, by simplicity of arrangement, can be rendered easily available.

In bringing his ideas before the public, he has adopted an arrangement, of which the following is a synopsis or general view. In the First Chapter are given a few brief remarks on the necessity for, and the importance of, Ventilation; with a summary of the evil effects produced upon the system by the body being subjected to the influence of "impure air." The Second Chapter is occupied with an explanation of the nature and principles of Ventilation, and of the most thoroughly practical plans for ventilating *public* buildings, illustrated with the necessary diagrams, with ample descriptions and suggestions. Chapter Third is devoted to the consideration of methods for securing a good supply of pure air to the interior of domestic structures; described in simple terms, yet with sufficient fulness to enable any one to carry them into effect. The Fourth Chapter contains descriptions of methods adapted especially to agricultural edifices.

The Fifth Chapter is on Heating—a kindred subject, and one of great importance in domestic arrangements, and in the arts; and which, moreover, when a good system is adopted, is a great assistant to efficient ventilation. In this department the principle of giving only *practical* remarks is rigidly adhered to: such, it is hoped, will be found to be of eminent service, and easily carried into effect. The construction of fireplaces, with a view to the economisation of fuel, and the prevention of smoke, is considered. And, with a few general Recapitulatory Remarks, the subject is closed.

Though somewhat foreign to the nature of the Work, an Appendix has been added. In this are given some remarks and suggestions, possessing some small degree of novelty, and capable of being applied to the ventilation of Ships, Steamboats, and Railway Carriages.

The whole is illustrated with Woodcuts, by which the descriptive text is made familiar, and the suggestions rendered easily available by he architect, the builder, and the agriculturist.

March 25, 1850.

PRACTICAL VENTILATION

CHAPTER I.

THE NECESSITY AND IMPORTANCE OF VENTILATION.

"It is not air
That from a thousand lungs reeks back to thine,
Sated with exhalations rank and fell;"
. . . . .
"It is not air, but floats a nauseous mass."
. . . . .
"Immersed in many a sullen bay,
That never felt the freshness of the breeze,
This slumbering deep remains, and ranker grows
With sickly rest."—ARMSTRONG'S *Art of Preserving Health.*

AMONG the natural agents necessary for the support and enjoyment of existence, with which a beneficent Creator has supplied us, the atmosphere by which we are surrounded performs an important part. Viewed as the medium of conveying, with equal facility, the rays of light, the vibrations of sound, the fragrances emitted from the shrubs and flowers of the teeming earth, and the gentle exhalations which, ascending to the clouds, form the aërial reservoirs from which the parched lands are supplied with grateful moisture, it presents to the inquiring mind a subject as interesting, in its general features, as beautiful in the precision of the laws which regulate its motions. But with reference to its influence upon the functions of the human frame, it presents another phase equally important and interesting. "It forms," says an eloquent writer, "the great *pabulum vitæ*, to which all other nourishment is subordinate, and without which death immediately ensues. Not only does it act constantly, wherever it presses upon the surface of the body—it is even brought into contact with the blood, within the inmost recesses of the lungs, where its renovating action purifies this vital fluid before it returns to the heart, from which it circulates in a living stream to every part of the body, producing a never-ceasing circle of chemical changes, so long as there is life to sustain its movements. Nor has nature been more profuse in its supply of that aërial fluid with which we are surrounded, than careful in the means adopted for its efficient application." What these are we will now see, in describing the *rationale* of the process of respiration, and the action of the air on the blood. The windpipe, passing into the chest, is divided into two branches, one going to the right, the other to the left lung. On entering the lungs, the branches are divided into innumerable little tubes, terminating in minute globular cells, all of which communicate with one another: the number of these is very great, the surface presented by the mass being computed, according to some, to be as much as 1500 square feet. Dr Reid, however, gives it as his opinion, that 400 square feet may safely be taken, as pretty near the truth. By the muscular action of the upper part of the body, the air is drawn down the windpipe through its innumerable branches, and the connected cells of the lungs, where it acts upon the blood, which likewise circulates through them. The two great canals, if we may use the expression, by which the blood is conveyed in its various courses, are the veins and arteries—the former conveying the blood to the lungs to be purified, the latter conveying the pure blood to the various parts of the body, giving off, in its course, "warmth, strength, and life." The colour of the blood in the veins is of a dark purple tint; in the arteries it is a bright red. If we could see the internal mechanism of our bodies in operation, we would perceive the veins pouring in the dark impure blood to one side of the heart, from thence forced to the lungs, there receiving the oxygen of the air contained in the cells; thereafter sent to the other side of the heart, from which it would be led off through the arteries a bright red colour. The air used in respiration, (drawn in, as we have seen, to the lungs,) is supposed, according to the generally received opinion, to impart its oxygen at once to the blood—the blood, in its course through the body, receiving various impurities, of which the principal is carbonic acid gas—these products being expelled principally by the elasticity of the lungs, assisted by muscular action of the body. Such, then, divested of all unnecessary elaboration, is a simple explanation of the *rationale* of respiration, and the action of the air upon the blood. The object of this process, (only suspended when death ensues,) which has been termed "the ventilation of the lungs," is to remove the "vitiated, which is exhaled into the lungs, and to supply a corresponding quantity of fresh air." Seeing, then, that the purification of the blood, which is the life-supporting fluid, depends upon its receiving a due supply of oxygen, it is evident that this purpose cannot be served by inhaling air previously deprived of that necessary component. It is of little use sending the blood to the lungs in which there is already bad air; such *must* result in deteriorated health.

But it is not only through the lungs that pure air exerts a beneficial influence upon the body, or *vice versâ:* the skin, pierced by its numerous pores, also exercises a function of considerable importance. Through its minute tubes, the air exerts an influence upon the blood similar to that which is per-formed, though with unremitting energy, by the lungs. From many controlling circumstances, these do not act with the same precision; but in a healthy person the inhalation of pure, and the exhalation of impure air, through the medium of the skin, goes on with considerable regularity. Lavoisier estimated that a man gives off, by insensible perspiration, fifteen grains of vapour per minute; and it has been ascertained that pure air, by being in contact with the skin, becomes chiefly carbonic acid gas.

A large supply of pure air, then, is as necessary for the due performance of the functions of the human body, as nourishing and wholesome food. This is evident, when we consider the process in continual operation in the living subject. We have stated that carbonic acid gas is the chief product of respiration: now, from the deadly nature of this gas, it must exercise, when inhaled into the lungs, a very deleterious influence upon the constitution. In its pure state it extinguishes flame, and kills almost instantaneously living objects presented to its influence. When more diffused, its effects are not so observable; nevertheless, they are "slowly and insidiously produced, and thus too generally overlooked, until the constitution is generally impaired, and the body equally enfeebled." "Independent," says the able writer from whom we have already quoted, "of the more serious evils, there are various minor evils, that often prey upon the constitution when the air is of inferior quality: the long-continued action of the vitiated air gradually undermines the tone and strength of the stomach; the appetite diminishes, and the citadel or mainspring of the constitution being thus disabled or destroyed, all the other powers of the system, also, gradually give way. Premature old age is, indeed, one of the most certain consequences of long exposure to a vitiated atmosphere; and in various occupations, the short span of human life is abridged many years by this cause, independently of the low tone at which it often flows, and the endless discomfort and annoyance to which, in such cases, it is often subjected. Nor are the moral and intellectual faculties to be forgotten, in considering the influence of a vitiated atmosphere. The energy and tone of both is lowered and depressed by bad air: these are impaired at least as much as the corporeal functions, and, when not subdued by the mere force of the oppression to which they are subjected, are often forced into an unnatural state of excitement, wholly incompatible with health, and with the sober exercise of the reasoning faculties."

The startling disclosures made within these few years, have abundantly proved the fact, that to defective ventilation may be attributed the widespread existence of more serious evils—we allude to typhus and other malignant and pestilential fevers. It has been computed that "the animal slaughter, in England and Wales, from preventible causes of typhus fever, which attacks persons in the vigour of life, is double the amount of what was suffered by the Allied armies at the battle of Waterloo." We believe this is no exaggeration. In Great Britain, there is every year a "battle of life" fought; the victims being the inhabitants of our towns—the victors, the deadly typhus and pestilence. "However appalling," says Dr Southwood Smith, "the picture presented to the mind by this statement, it may be justly regarded as a literal expression of the truth. I am myself convinced, from what I constantly see of the ravages of this disease, (typhus,) that this mode of putting the result does not give an exaggerated expression of it. Indeed, the most appalling expression of it would be the mere cold statement of it in figures."

In addition, however, to the influence of impure air in generating disease, it materially contributes to its propagation. A certain degree of concentration generally appears to be necessary for, and invariably predisposes to, the occurrence of an attack of fever. In confirmation of this, we adduce the following evidence of Dr Arnott's:—"In a public building at Edinburgh, when the number of cases of fever began to exceed a certain proportion of all the cases of disease in a ward, the fever began to affect the nurses, who were constantly present, and therefore much exposed to the infection; when the proportion became still greater, it affected also the students, who were less exposed to it than the nurses, but more than the physicians; and, when increasing still further, it affected also the physicians." This was when the wards were occupied chiefly with fever patients. "But when such patients were scattered about, so as to dilute the poison, the attendants remained safe, as did also the neighbouring patients in the beds about them: thus proving that dilution of the contagious poison, by scattering the patients, as well as the complete ventilation of a fever ward, affords safety."

But fever is not the only disease rendered more extensive in its ravages by defective ventilation: such is "but a drop of water in the ocean, compared with the other less obtrusive but more dangerous maladies that silently disorganise the vital structure of the human fabric, under the influence of this deleterious and invisible poison." The most important of these are, consumption and scrofula. With reference to the first, Dr Guy states that almost all cases amongst the working classes are occasioned by confinement in over-heated workshops, at sedentary occupations; but its ravages extend to all classes, the rich and wealthy suffer likewise. It is in connexion, however, with scrofulous diseases that the evils of impure air are so strikingly observable. Joseph Toynbee, Esq., a gentleman who has devoted much of his time to the consideration of the subject, gives the following evidence, supported by that of a celebrated French physician:—"Defective ventilation appears to me to be the principal cause of the scrofulous affections which abound to an enormous extent amongst our patients. When I have had a scrofulous patient come before me, I have always been able to trace this as one of the agents. When it is seen, on the other hand, that this disease never attacks persons who pass their lives in the open air, and manifests itself always when they abide in an air which is unrenewed—and this, whatever may be the *extent of other causes*—it appears evident that the non-renewal of the air is a *necessary condition* in the production of scrofula. Invariably it will be found, on examination, that a truly scrofulous disease is caused by a vitiated air; and it is not always necessary that there should have been a prolonged stay in such an atmosphere—often a few hours each day is sufficient. And it is thus that persons may live in the most healthy country, pass the greater part of the day in the open air, and yet become scrofulous, because of *sleeping in a confined place*, where the air has not been renewed." An example of the truth of these statements may be given:—"At three leagues from Amiens lies the village Oresmeaux. It is situated in a vast plain, open on every side, and elevated more than 100 feet above the neighbouring valleys. About sixty years ago, most of the houses were built of clay, and had no windows; they were lighted by one or two panes of glass fixed in the wall; none of the floors, sometimes many feet below the level of the road, were paved. The ceilings were low—the greater part of the inhabitants were engaged in weaving. A few holes in the wall, and which were closed at will by means of a plank, scarcely permitted air and light to penetrate into the workshop. Humidity was thought necessary to keep the threads fresh. Nearly all the inhabitants were seized with scrofula; and many families, continually ravaged by that malady, became extinct; their last members, as they write me, died *rotten of scrofula.* A fire destroyed nearly a third of the village; the houses were rebuilt in a more salubrious manner, and by degrees scrofula became less common, and disappeared from that part."

We could fill a volume with facts illustrative of the baneful effects of vitiated air on the health of the human frame; but we have, we opine, cited enough. When it has been affirmed that "non-ventilation is a more fatal cause of disease than any other"—when, in addition to those already noticed, it is shown to be productive of many minor evils—as cattarh, rheumatism, disordered digestion, nervous complaints—diseases of the joints, of the skin, of the delicate organs of the eye and ear—and, to sum up the dreary list, a "predisposing and aggravating cause of every species of bodily affliction to which mankind are subject," surely the reader will be convinced of the great necessity existing for efficient ventilation, securing everywhere to the habitations of man a large supply of pure air.

If the beautiful process of respiration has been ordained and set in motion within our "earthly tabernacle" for the purpose of freeing it from impurities which would cause disease and pain if allowed to remain; is it not worse than folly to act in our daily lives counter to this plan, and, refusing the pure air given us, perversely choose that which, impure and deteriorated, only induces disease? And yet this is done every day. In the great majority of houses, no provision whatever is made for the admission of fresh air. It has been calculated that no less than 400 cubic inches of air is required by each individual per minute; yet actual observation has proved that, "in an immense majority of houses in different towns, the quantity of fresh air admitted did not amount to more than one fourth of the *minimum* required." While studying the subject of atmospheric influence upon the body, nothing strikes the inquirer more forcibly, on becoming alive to its importance, as the indifference with which a supply of pure air to the lungs is considered by the great majority of people. Could a person, ignorant of the process, see vividly presented to his mind the poisonous action of impure air upon the blood, we feel convinced that he would be startled by the contemplation of the facts presented to his notice. He would, in very truth, see that he might, with as much certainty of ultimate punishment, mix diluted active poisons with his meals, as breathe air deteriorated in its quality. This is no exaggerated mode of putting the matter; it is sober truth, too often, alas, proved by the pale-faced, the emaciated, and diseased around us. It is amazing with what indifference people look upon the existence of impure air in their dwellings. Presenting nothing tangible or visible, so long as its influence does not result in marked or immediate effects, they are content to abide its presence. Many who pride themselves on their fastidious taste, in other objects necessary for the support of life, will, with a freedom as astonishing, as it is melancholy in its results, breathe air most foul and impure in its quality. It is, however, gratifying to the philanthropic mind, to find the ignorance existing on this important subject becoming gradually dispelled; that the veil so long hiding the real merits of the question is fast being removed; the evils of the old system becoming daily more understood and dreaded, and a desire for a better order of things more manifested. On the other hand, comparatively little *practical* advantage has been taken of the knowledge so extensively enjoyed; "the rough and rude treatment to which the lungs are subjected, the vitiated atmosphere which they are so often called to inhale, and the transitions of atmospheric and artificial temperatures to which they are carelessly subjected, show clearly how little the value of a mild and fresh atmosphere is practically appreciated; while the ravages of consumption, and the extended catalogue of evils accompanying diseases of the organs of respiration, point out the vast amount of misery that might be obviated, and of death that might be prevented, were the leading principles and practice of ventilation more generally understood."

With the expression of the hope, that *practical* knowledge will become more and more extended and made use of in daily life, we close this part of our subject by quoting the words of Dr Southwood Smith—a gentleman to whom our country owes much, for his philanthropic exertions in connexion with the amelioration of the condition of the poorer classes of society: "Nor is there one, among the many questions thus forced upon the attention of every civilised community, which is itself so important, or the correct solution of which is so indispensable to the preservation of health, as the investigation of the best and simplest means for providing, in every space occupied by human beings, a gradual but constant change of air. Innumerable are the catastrophes, some of sufficient magnitude to occupy the page of history, which testify to the necessity for man carrying out, in his dwelling, the same principle upon which nature has proceeded in the fabrication and endowment of his body. She has, by a simple and efficacious process, provided for the ventilation of his lungs; and it is for him, *using the reason with which he is blessed*, and imitating the beneficent provisions indicated by science, to direct through every place which he inhabits a gentle current of that invisible atmosphere, which was intended to be the source of life, but which has hitherto been too frequently *a transmitter of disease and death*."

CHAPTER II.

VENTILATION OF PUBLIC BUILDINGS.

"The trembling air that floats from hill to hill—
From vale to mountain, with incessant change
Of purest element."—ARMSTRONG.

BEFORE entering into the explanations of practical details, we deem it necessary to review shortly the causes of the existence of vitiated air in the interior of public buildings; and to explain the *rationale* of the process of ventilation. Air is principally deteriorated by the evolution of carbonic acid gas from the lungs, one of the chief productions of respiration. This gas, as we have before mentioned, cannot support life or combustion; it possesses such a deleterious influence, that, even when placed in contact with the exterior surface of the skin, it inflames and reddens it. "In general, when any attempt is made to inspire pure carbonic acid gas, a convulsive movement induced at the entrance to the windpipe closes the aperture, and prevents ingress. In some cases, there is reason to believe that the movement has not been sufficient to exclude the carbonic acid, and immediate death has ensued. It is not known that there is any hope of recovery where carbonic acid freely enters the lungs. Death has ensued, in some particular cases, where there was only one per cent of the gas present. Any ordinary atmosphere containing one per cent of carbonic acid must be regarded as of very inferior quality, and not fit to sustain health, though, in numerous apartments, a much more vitiated air may be observed. The lower the tone and strength of the constitution, the more alive does it become to the depressing influence of air contaminated with carbonic acid. The old and the infirm sometimes sink in an atmosphere of which the robust and vigorous may take no notice. When the quantity of carbonic acid is reduced to a proportion varying from the one-thousandth and two-thousandth part, it does not produce deleterious results. Common air contains a minute proportion of the gas, even at the highest altitude at which it has been examined. Carbonic acid gas being the principal impurity communicated to air in all ordinary apartments, the amount present may in general be taken as an index of the state of the atmosphere and of the efficiency of any ventilating arrangements." A simple mode of testing may be adopted: a perfect analysis is not required. Lime water, placed in an open dish, will show the presence of the gas. Air is also deteriorated by the volatile products emanating from the pores of the skin. The mode of lighting also tends to the same result: the flame of a gas jet, equal in brilliancy to a common candle, renders from 200 to 300 inches of air per minute unfit for respiration. The mechanical impurities found in buildings, as dust, &c., also to a certain extent vitiate the air used. Having thus reviewed, very briefly, the causes of the existence of vitiated air in public buildings, we will now proceed to explain the process of ventilation.

Air, when expelled from the lungs after being used for the purposes of respiration, being composed principally of a heavy gas, it has been argued that the specific gravity is such that it has a downward tendency. Now, although carbonic acid gas is more than one-half heavier than water, still, in its passage through the lungs, it acquires as much heat as to give it an upward tendency of very considerable force. This may be very familiarly illustrated, by breathing in the open air on a calm day in frosty weather: the breath will be seen floating upwards. This may be rendered more convincing: by blowing the breath forcibly downwards, the same result will be obtained. That this law has been ordained for benevolent purposes we cannot for a moment doubt; the mixture of vitiated air is found to be much lighter than that of common pure air at the same temperature. In this arrangement we have to admire another of the simple, yet beneficent laws, appointed to minister to our comfort. Air, when vitiated, having thus a high temperature imparted to it, rises, when allowed to escape, with such velocity, as soon to be borne away above the zone of respiration, so that, in such cases, it cannot be breathed again. It is for man, then, to take advantage of this simple law, and, by allowing free egress to the vitiated air, supported by other modifications, to free himself of this active agent in producing disease.

Ventilation may be divided into two classes—*artificial* and *natural*. By artificial, currents of air may be exerted in any direction—upwards, downwards, or laterally; this being effected by machines and contrivances, as pumps, fanners, screws, and we may here specify fire-draught. Artificial ventilation is divided into two branches, "plenum" and "vacuum." Plenum ventilation may be briefly described as the mode where air is forced into the interior of a building, the vitiated air being allowed to pass out by the channels made for that purpose, or by the crevices of the doors, windows, &c. "The certainty of introducing," says Dr Reid, "without mixture, the air that is considered best, forms the great peculiarity of plenum ventilation, which can be sustained only by the constant use of machinery." The vacuum impulse is sustained by machinery, which pumps or extracts the air from the interior—allowing the fresh air to enter by the crevices of the doors, or by apertures provided for that purpose.

Natural ventilation does not, however, depend upon machinery for its results, but is "a process by which movements are induced or sustained in the air, in the same manner as wind is produced in the external atmosphere." The *rationale* of natural ventilation cannot be better described than in the words of Dr Reid: "The specific gravity of air vitiated by respiration and combustion, the two great processes that deteriorate air in ordinary buildings, is under ordinary circumstances less than that of common air: it gives way accordingly, and is pressed upwards by the denser and purer air. Let us imagine, then, an apartment occupied by a number of persons standing on a porous floor, and the roof taken off: at ordinary temperatures, the air, vitiated there by the human frame, requires no mechanical power to remove it. The superincumbent pressure is diminished by the expansion induced in the air as it is heated; but the external air is permitted to have free access below, as well as above, to the porous floor. Its power therefore preponderates, and an upward movement is the necessary consequence; which is accompanied by the introduction of fresh air and the removal of that which is vitiated. Here, then, is a species of natural ventilation. All that is essential is merely this, that the natural movements induced by the heat of the body shall not be stopped by any barrier opposed to them. An open roof and ceiling is, however, inadmissible: protection is required from the weather, independent of other arrangements. The opening, accordingly, may be contracted: in proportion to the amount of contraction, the temperature of the air, and the numbers on a given space, it now becomes necessary to increase the velocity of the discharge from the apartment referred to. To effect this, if a shaft or chimney be extended from any opening in or near the ceiling, the column of warm air which soon fills it increases its power; and unless an extreme number of individuals be crowded in the apartment, the shaft *is sufficient for all ordinary purposes.* It acts at all times, if the air within is less than the density of the air without; and, when this is not the case, its power can still be developed by kindling a lamp or fire, or merely by increasing the temperature of the apartment for which it is applied—as any of these causes produces the necessary diminution of density or rarefaction within, on which its force depends." Such is an admirable explanation of natural ventilation. In all cases where the nature of the building will admit of it, natural ventilation should be adopted, and the simple laws which regulate its motions taken advantage of. We venture to say, that nine buildings out of ten can be efficiently ventilated without the aid of any machinery whatever. A writer on the subject, in passing severe strictures on *builders*, in endeavouring as much as possible to close up every aperture by which air can gain admittance to dwelling-houses, says, "that luckily, in spite of all their endeavours, their close-fitting doors and windows, air still finds access." And so it is: the laws founded for a benevolent purpose will act, however much man may retard and oppose them. Is it not consistent, then, with natural laws, to suppose that if air *forces* itself into apartments, when every means are taken to exclude, and, when once in, to confine it; that surely it will gain easier admittance when apertures are formed to facilitate its admittance, and, when deteriorated, to allow it likewise to escape? And yet many strenuously advocate the use of machinery, more or less complex, in almost all cases, when ventilation is required; as if it were an absolute impossibility to supply air to their interior without such mechanical appliances. The writer whose definition of natural ventilation we have given, says, that the ascent of air in shafts, at the ceiling, acts in *all cases* where the density of the air within is less than that of the air without. Now this opinion is that of one who has had more experience in practical ventilation than any other we are aware of, and it is amply corroborated by the result of every day's experience. The cases will be very rare indeed, where the conditions requisite, as implied in the above, will not be fulfilled. In winter, the heated air in the interior is sure to be of less specific gravity than the cold air on the exterior; and even in summer, although the heat of the breath in the interior, and that of the air in the exterior of the building, may be nearer in equality than in colder weather, there is, and must be, a decided difference in favour of that in the interior. This is amply proved when the fact is considered, that it is much hotter in a crowded building than in the open air, however calm, in a hot summer-day: the heat of the bodies, in a certain degree raised in temperature, in proportion to the number of people assembled, and the concentration of the heat by the confinement, all tend to the result found.

Not only can buildings be ventilated efficiently, by the adoption of the laws in constant action, but, what is of considerable importance, the expense of doing so is comparatively trifling; moreover, when once effected, repairs are not required, or the expenditure of any expensive power to maintain its operations, necessary. Again, there are no complicated arrangements, difficult to be understood by that class who, in all public buildings, will generally be found to have their management. But, apart from these considerations, we would advocate the adoption of the simple plan on grounds of policy. So long as the public opinion, too generally current, is believed, that ventilation is an exceedingly complicated science—an important one, doubtless, yet requiring erudite knowledge to apply its principles practically, and in the adoption of which great expense is incurred, and complicated machinery requisite—so long will the apathy generally existing on this important subject continue. It is exceedingly difficult to persuade people to lay out money for the prevention of evils of which they are not *too well* convinced, and which are invariably attributed to other causes. Moreover, if the idea is once obtained, that the operation of ventilation is very expensive, however much they may be alive to its importance, the very dread of the expenditure suffices to allay their fears, or is at least productive of the effect evidenced by the saying—" Oh ! there is *no use* at all in thinking about it, *it is so* expensive." Let, however, the fact be generally understood, that ventilation is within the reach of almost the very poorest mechanic in the land, and a new spirit of inquiry will soon be abroad. By the numerous cheap publications which find their way into every house, people heretofore ignorant are becoming aware of the importance of the subject; and if they are likewise made aware of the cheapness and facility of construction of useful plans, a demand will soon arise for such. We have had ample proof of the truth of this in the experience of the Samaritan Fund, established in London, for supplying the habitations of the poorer classes with "ventilators:" the demand made by poor people is every day increasing, and there is reason to believe that it will continue to do so. Let those who are anxious to promote the introduction of plans, endeavour to promulgate as much as possible those more remarkable for their simplicity than complexity. We do not say that we can obtain, *without* machinery, those complicated movements of air, which can be moved or drawn with precision in *any* direction; but such are not required. Let a desire for *thoroughly* efficient plans be introduced gradually; let the benefits of a supply of air, though not so nicely controllable in its motions, be appreciated, and we have no fear that, in process of time, a demand for more complicated plans will be created. In no important movement is success all at once obtained; the old proverb, "Little by little," is a good one, and from which something may be learned. Let all endeavours to divest the subject of apparent difficulties be strenuously made: by the introduction of simple plans, curiosity will be excited, inquiries will be made; and that indifference, too justly complained of, which is now existing, will be done away with, and the adoption more generally of efficient modes be the decided result.

Having, then, avowed a preference for the plan of ventilation which (by availing ourselves of natural laws, simple and unvarying in their action) can be easily and cheaply adopted, we will now proceed to the more immediate consideration of our subject.

In ventilating buildings, two things should be borne in mind; and as upon the proper attention to these depends the success of the plan, particular attention should be taken to see them carried into effect. These are, the supply of the interior with fresh air, and the withdrawing of it when vitiated. And here we would request attention to the fact, of which the evidence of all experience goes to prove the truth—that no *foul air can by any possibility be extracted from the interior of any building, however well arranged the means to insure its exit may be, unless an ample supply of pure air is admitted.* "A moment's reflection will satisfy the *mere student* as to the truth of this position. . . . It is the force of air entering that causes the vitiated air to be expelled. It is necessarily impossible to have ventilation without a movement of air. At all times a tendency to movements in the air, or the production of a draught or current may be oberved, proportional to any inequalities of temperature that may arise from natural or other causes, or the action of any mechanical force." In making provisions for the supply of pure air, due regard should be had to the source from which it is supplied. If much dust or extraneous mechanical impurities should be at the base of the building, or drains near to or passing through there, the air should be led from a distance from the ground. The woodcut annexed will show how this can be effected. The entrance to the conduit, or "fresh air ventiduct," is below the eaves. In buildings already constructed, forming these ventiducts would be attended with considerable expense, to save which, apertures may be made at the lower part of the walls. And in order to stop as much as possible the ingress of all extraneous particles of dust, &c., through these, there should be stretched across the *inside* of the opening, sheets of very

finely perforated zinc, or horse-hair cloth. Where the air has to be led into the interior of a church, say to the passages, ventiducts must be employed to conduct the air to the required place. These conduits may be made of zinc or iron pipes; but a cheaper mode is to make wooden boxes of sufficient size. To prevent the damp from affecting these, the outsides should be covered with two or three coats of a composition of tar and sand, (three of the former to one of the latter.) The best place, in the generality of churches, to lead the air to, is the passages; and, indeed, in most of other public buildings. The apertures at the place of ingress to the interior should be covered with cast-iron gratings. These can be made of a very handsome design, which may be described as a parallelogram, divided into diamond-shaped lozenges, by bars; in the centre of each of which are rosettes, which, passing across the shortest diameter of the diamond's openings, leave the corners at the longest diameters open for the passage of the air. But in order to diffuse the air as much as possible in its passage through the gratings, along the under side of these, plates of zinc, with small perforations, should be fixed, or sheets of horse-hair cloth. For this purpose we would also recommend the adoption of "cocoa-nut fibre matting"—it is very cheap, porous, and can be made of any closeness of texture: it is becoming much used for the passages and aisles of churches. If used in this way, any species of grating, however rough, would do, as it would be hidden by the cloth laid above it. One thing in connexion with the gratings should be borne in mind, that is, to have the apertures greater, at least equal in surface to those on the outside.

Having described the ventiducts for the admittance of fresh air, we will now give the valves for regulating the admission to these, according as it is required; and, first, as to the valve designed for the ventiduct, the opening of which is at a distance from the ground. Fig. 1 is a side section of a very simple contrivance for this purpose: *a a* the wall, *d* the iron staple supporting a bracket for hanging the wheel *e;* this bracket is fixed in the wall *above* the aperture, and at its centre; a chain or rope, *c c*, is passed over the wheel or pulley *e*, and attached to the hinged valve *b*—the rope should be continued till within a short distance from the ground, and provided with a weight at its lower extremity, counterbalancing the weight of the valve *b*. A glance at the figure will enable the practical man to perceive its action. A variety of contrivances may be adopted for regulating the admission to fresh air ventiducts, situated at the base of the walls near the ground—we however only give two. Fig. 2 is a representation, in section, of one of these: *a a* is the wall, *b b* an iron quadrant fixed in the wall at the end of the aperture; this quadrant has a groove or slit, as shown by the dotted line; this allows a thumb or pinching screw, attached to the hinged valve *c c*, to traverse up and down therein; the valve

Fig. 1.

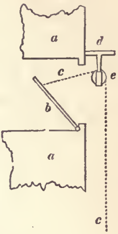
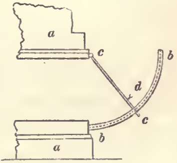
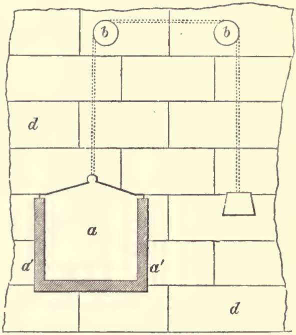


Fig. 2.



is moved by the handle *d*, and is fixed in any position by the thumb-screw. Fig. 3 is a front view of what we call the "damper valve," as it is made on the same principle as the damper of a steam-engine furnace: *a* is the damper valve, made of sheet of cast or malleable iron, some two or three eighths of an inch thick, and of size proportioned to the size of aperture; *a′ a′* is the frame, leaded into the wall, in which the valve plays; *b b* small wheels or pulleys round which a chain or rope passes, at the end of which a counterpoise weight is fastened, the other end being attached to the damper valve; *d d* the wall. The action of the plan is so simple that it requires no further explanation. The apertures for the admission of fresh air should be disposed at equal distances round the building, if possible on all sides, so that, from whatever quarter the wind blows, an aperture may be placed so as to receive its influence: not that the force of the wind is necessary, for air,

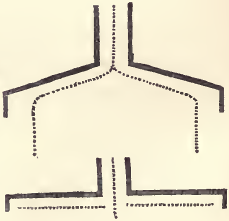
Fig. 3.



as we have shown, will find its way wherever it is required, unless prevented; but in windy weather more air will be *forced* in, in a given time, than in calm weather.

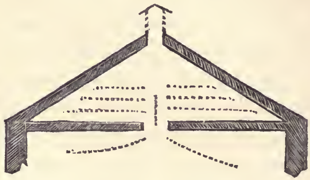
Having provided means for the admission of fresh, we will now direct attention to the means for withdrawing the foul air. The apertures for its escape should be placed in all cases at the highest part of the ceiling. We have already hinted at the plan argued by some to be the best, namely, withdrawing the foul air from the bottom of buildings, on the supposition that, as the carbonic acid gas is heavier than common air, it must necessarily fall to the lowest portion of the interior. Plausible as this plan *seems* in theory, in *practice* it is found altogether erroneous. That this is the case, our notice of the laws of air, which we have already given, abundantly proves. But as there is much doubt, even still, in some cases existing, we here give a remarkable instance of the absurdity of the plan, extracted from the evidence of Dr Arnot before the Committee. "In the Zoological gardens in the Regent's Park, a new house was built to receive the monkeys; and no expense was spared which, in the opinion of those intrusted with the management, could insure to those natives of a warm climate all attainable comfort and safety. Unhappily, however, it was believed that the objects would be best secured by making the new room nearly what an Englishman's drawing-room is. For warming it, two ordinary drawing-room grates were put in, as close to the floor as possible, and with low chimney openings, that the heated air should not escape by the chimneys; while the windows, and other openings in the walls above, were made as close as possible. Some additional warm air was admitted through the openings in the floor, from around hot-water pipes placed beneath it. For ventilation in cold weather, openings were made in the skirting of the room, close to the floor, with the *erroneous idea* that the carbonic acid gas produced in the respiration of the animals, because heavier than the other air in the room, would separate from this, and escape below. When all this was done, about sixty healthy monkeys, many of which had already borne several winters in England, were put into the room. A month after, more than fifty were dead, and the few remaining ones were dying. This room, open only below, was as truly an extinguisher to the living monkeys, as an inverted coffee-cup, held over and around the flame of a candle, is an extinguisher to the candle. Not only the warmth from the fire, and the warm air allowed to enter by the openings in the floor, but the hot breath, and all the impure exhalations from the bodies of the monkeys, ascended first to the upper part of the room, to be completely incorporated with the atmosphere there; and by no possibility could escape, except as part of that impure atmosphere gradually passing away by the chimneys and the openings in the skirting: therefore, from the time the monkeys went into the room until they died, they could not have had a single breath of fresh air. It was necessary only to open, in the winter, part of the ventilating apertures near the ceiling, which had been prepared for the summer, and the room at once became salubrious."

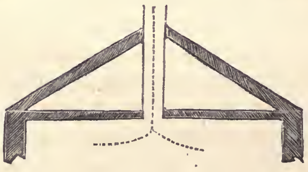
After this long, but, we hope, not useless digression, we will return to our practical details. A glance at the accompanying sketches will enable the reader at once to perceive the great difference between flat and coved or sloping roofs. The heated air-currents, striking in the flat roof, are driven for a small space downward, creeping along till they reach the ventiduct; on the contrary, with a sloping roof the currents, wherever they strike, are enabled to slide gently upwards to the ventilator, which, in such cases, must be higher than any part of the roof. The dotted lines show the progress of the currents. If the nature of the building will



admit of it, the area of the aperture should be distributed over the ceiling in more than one place. Supposing the area of aperture of a church is required to be 3 square feet—if three apertures, of 1 square foot each, be placed along the roof at regular intervals, the building will be more speedily ventilated than if one aperture of 3 feet square was alone used. This is evident when we consider that the various columns of heated air, in ascending, would have to move towards the one aperture from *all* parts of the interior; while, if there were more than one, each hole would command a certain space near it of no great area.

In cases where there is an inner roof or ceiling—thus forming an empty space between it and the external roof—the foul air should on no account be allowed to enter in it, as, by spreading itself beneath, and coming in contact with the cold roof, its ascending power will be very much diminished. The plan almost in all churches carried into effect, where ventilation *is attempted*—of having louvres, or spaces in the external roof opening into the space between the roof and ceiling—and through the latter to the interior, by the holes made in it—is just as wise as that which would be adopted by a miller, who, instead of leading the water to his mill in one large dam, endeavoured to do so by conducting it in a series of little rills or small pipes, regardless of the loss sustained by friction and waste. We have seen, in such cases, apertures or long slits made in the upper part of the ribs or mouldings used in architectural decorations; but, excellent as this idea appears, it is comparatively useless, inasmuch as the air which does pass through them, entering the large cold empty space, is so diminished and weakened in its ascending power as materially to weaken the ventilation, even where proper apertures are made below to admit fresh air. The sketches here

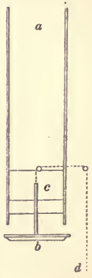




given will amply illustrate the superior advantages of leading the foul air through the empty space by means of a wooden or iron box or pipe; the sketch above is a representation of the old plan we have condemned: the dotted horizontal lines show how the air spreads itself along the space. But, bad as this plan is, it is good compared to one we have frequently met with in our practice, in which a ventilator, generally ridiculously small, has been attached to the outer roof, communicating with the empty space, but the inner roof or ceiling provided with no aperture communicating with the interior of the building—the interior of the church, with reference to its connexion with the ventilator, being as good as if it had been hermetically sealed. The absurdity of this plan is so apparent that it is needless to condemn it, otherwise than by the mere mention of it. It may, however, be adduced as one of the proofs we could bring forward of the utter ignorance of many architects and builders as to the philosophical principles of ventilation practically applied.

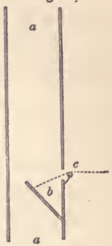
In constructing the ventiducts for the withdrawal of foul air, means should be provided for regulating the velocity of the passing current. Fig. 4 is a section of a contrivance recommended by Tredgold: *a* is the ventiduct or wooden box; a board *b*, ornamented on the under part, larger in diameter than that of the ventiduct, is hung in the manner shown, by a rope or chain passing over two pulleys, one of which runs on a small iron rod stretched across the interior of the box. The other is placed just above the opening made in the ceiling

Fig. 4.



near the wall, through which the cord is passed into the interior of the church, and conducted to a height sufficiently easy to be reached by the attendant, and terminated by a counterbalance weight; *b* is the valve, *c* the rod for suspending it, sliding through two holes made in bars stretching across the ventiduct. Fig. 5 is a section of a different construction, which we would recommend as convenient and efficient: *a a* is the ventiduct; a valve *b*, made of wood, is fitted to the interior, and hinged at one side. The end for working it passes through a hole cut in the side of the box, and is taken over a pulley, fixed there and supported by a small bracket. The cord is led to the opening in the ceiling, over which is another pulley, on which it rests, and conducted to any part convenient in the interior.

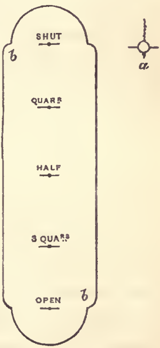
Fig. 5.



In cases where the latter ventiduct is used, the contrivance shown in the annexed sketch should be adopted. A piece of wood, considerably larger in diameter than the aperture of the ventiduct, (at least one-third,) should be firmly suspended about 14 or 18 inches from the opening, according to circumstances. The use of this is very obvious. The opening of the tube, if left open, would

have a tendency to draw away the column of air only immediately under it; while, by means of this, the air is drawn horizontally as it were, creating a horizontal current calculated to draw off the whole air near the ceiling. The dotted lines will show the mode of action. The under side of the wood should be ornamented with some light ornaments, properly fixed, as, by falling from such a height, they might seriously hurt those underneath if becoming detached. Great care should be taken to have the board itself properly fastened.

As a means of ascertaining the exact degree of opening of the valves, in the foul-air ventiducts, the index-plate, of which the following is a sketch, will be useful. To the counterpoise, at the end of the rope or chain used in working the valves, have pointers, as at *a*, attached; provide a tin plate, cut in the shape as shown at *b b*; shut the valve, and on the wall place the tin plate with the upper mark *shut* opposite the pointers. Then open the valve *half*, as may be seen by a party placed near the ventiduct; at the place where the pointers rest, paint the word *half* on the tin plate; do the same at the other two points, quarter and three-quarters, and

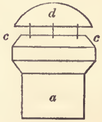


at *open*. The spaces between these may, for greater accuracy, be divided into equal parts; but this, in the generality of public buildings, will be unnecessary.

In ventilating churches, where galleries are constructed, care should be taken to provide these with a separate supply of fresh air; as, if this is not carefully attended to, the parties there situated must inevitably breathe air, a portion of which at least must be foul, coming, as it will be forced to do, from the under part of the church. The simplest mode to insure a good supply of air, will be to make apertures in the wall opposite to the passages running down towards the edge of the galleries—these should have ventiducts leading directly to holes made in the back part of the steps, generally made in the transverse passages in church galleries. The easiest mode of doing this (taking care to confine the air as much as possible till it is carried to the point of egress) will readily occur to the carpenter who may be employed: the arrangements will, of course, vary in almost every case, but the principle is the same. In cases where there is a flat roof running above the galleries, ventiducts should be distributed for the purpose of leading off the foul air—these should be smaller than those in the main ceiling. The following may be considered as a fair proportion:— Supposing there are required foul air apertures of twenty feet square in area, for a church containing fifteen hundred people, the area of apertures for the main ceiling would be in proportion to the number of people in the lower part of the church; if two-thirds were assembled below, twelve square feet would be the area; the remaining eight would be distributed over the galleries.

The rules for ascertaining the area of exit apertures or foul air ventiducts for a church, is as follows:—" The power of ventilation," says Tredgold, " should obviously be adapted to the greatest number of people the building is to contain at one time; and it is obvious that we had better err in excess than deficit." Perhaps an example, in round numbers, will afford a more distinct view of the quantity of air it is desirable to change in a crowded room. According to deductions made by the same eminent engineer, four cubic feet of fresh air will be required every minute for each individual; therefore, when a room contains two hundred people, eight hundred cubic feet of air will require to be supplied, " or a little more than would fill a room nine feet square and nine feet high:" four hundred people would require sixteen hundred, and so on. We are aware that four cubic feet per minute will be, by some, thought to be too much; Dr Reid mentions ten cubic feet. It may be as well, however, to give the reasons by which Tredgold was induced to give such a proportion. It has been shown, by repeated experiments, that " a man consumes about thirty-two cubic inches of oxygen in a minute, which is replaced by an equal bulk of carbonic acid gas from the lungs. Now, the quantity of oxygen in atmospheric air is about one-fifth; hence it will be found that the quantity rendered unfit for supporting either combustion or animal life, by one man in one minute, is nearly a hundred and sixty cubic inches, by respiration only. But a man makes twenty respirations a minute, and draws in and expels forty inches of air at each respiration; consequently, the total quantity contaminated in one minute, by passing through the lungs, is eight hundred cubic inches." The absolute quantity of air rendered unfit for respiration by the perspiration of the body, &c., has not yet been fully ascertained." "It must, at least, be desirable to change as much of the air of a room as the moisture given off would saturate in the same time; and in a room at sixty degrees, on the supposition that, in consequence of the body being chiefly covered, the moisture given off does not exceed eighteen grains, it will be necessary to change three cubic feet of air per minute for each individual in the room." And for the deterioration of air by lighting, he allows one-fourth of a cubic foot per minute for each individual; and the total amount he thus obtains is 6416 cubic inches, or nearly four cubic feet per minute.

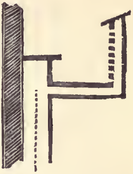
As the rate of ascension of the vitiated air, in the tubes prepared for its exit, depends upon the difference of temperature of the external air, and of that in the tubes, or interior of the building, the greater the difference the greater the velocity of ascent; it follows, then, that in summer it will be more difficult to ventilate a building than in winter. On the assumption that there will not be a greater difference in summer, between the external and internal air, than ten degrees, Tredgold founds the following rule,—"*Multiply the number of people the room is to contain by* 4, *and divide this product by* 43 *times the square root of the height of the tubes in feet, and the quotient is the area of the ventilator-tube.*" By the height of tubes is meant the height from the floor of the room to the place where the air escapes to the atmosphere. If there are more tubes than one—that is, if the area of the exit aperture found by the above rule can be divided, and disposed in more than one, the different ventiducts should be all of the same height, as, if they are not of the same length, the tall ones will overpower the short, and adverse currents will ensue. The whole of the ventiducts should reach at least 18 inches above the roof from which they project, and be properly finished at top to prevent the wind blowing down them, or rain, snow, &c., descending. The annexed figure is an elevation of a top recommended



by Tredgold, and which has been successfully and largely used: *a* is the under part for fixing it to the ventiduct. The inside diameter of this should be of size sufficient to slide tightly over the outside diameter of the ventiduct, and there firmly fastened by screw-nails; the cover *d* made circular or conical, prevents any down draughts; and the angular edges *c c* create an upward current in the tube, when the wind blows, by the course which it is caused to take. These slopes *cc* should be made more angular than shown in the sketch. The tops should be made of metal, as zinc or tinplate, well painted black. The tops recommended for chimneys in Chapter V. of this work will do well for furnishing ventiducts. The area of the apertures for fresh air, if the air is led to the passages or interior by tubes or ventiducts, should be equal to, or even a little less than those of the foul air ; if the air is admitted at once from a simple aperture to the interior, allowing it to spread itself at once, the area should be double that of the foul air ventiducts. The air contracted in the tubes will rush in with greater velocity than simply through an aperture: this will compensate for the difference in size.

We have, in these practical details, treated of them as applied to churches alone; the practical man will at once see how the same suggestions and rules can be made applicable to the ventilation of any public building. We will shortly, however, in connexion with hospitals, theatres, &c., throw out some additional hints.

"No buildings, on an average, are more deficient in the means of ventilation than churches. Air, loaded with carbonic acid and the moisture of the breath, and with products from the combustion of gas, oil, or candles—chilling draughts from immense surfaces of glass, inequality of heat, emanations from graveyards," may all be observed producing deleterious effects." To these may be added the hot, burnt, and too frequently unhealthy air sent in from the imperfectly constructed stoves generally found to be used for heating churches. The importance of ventilating places of worship has not been too fully insisted upon. Dr Reid eloquently descants upon the evils of non-ventilation: we would hope that Christian people and Christian ministers will benefit by such remarks, and believe it to be their privilege, as it certainly is their duty, to render the places in which God is worshipped, in every way calculated to assist the reasoning faculties, the intellect of those assembled therein; and not, as too often is the case, subjecting them to influences affecting not only the body with disease, but the mind with a lethargy and an indifference too painfully contrasted with the importance of the subject which they assemble to hear explained. "Few spectacles are perhaps more melancholy than those presented in such cases as these, (crowded, ill-ventilated churches.) The congregation is not unfrequently placed in an atmosphere of extreme impurity, poisonous in its tendency, arresting or interfering with some of the most important functions of life, to such an extent that they are occasionally suspended for a time, when a temporary death, or fainting, takes place. But what must the state of the mind have been, and how far was it beneficially occupied in the devotional exercises in which it was previously engaged? The power of the clergyman is often reduced, as well as the attention of the congregation. Too often he does not recognise the darkness of the physical atmosphere that at times oppresses all his labours, and counteracts or diminishes his usefulness, as much by the power with which it subdues his own energies, as by the careless indifference which it encourages in his congregation. At the very moment he may be descanting on the pernicious influence of vice, and pointing out the purifying power of that moral influence which should surround the heart, how often are his labours shorn of their power by the physical poison that sometimes paralyses the best intention, the indications of which are manifest in the application of the most ordinary tests, and whose influence might be counteracted by means equally simple and efficacious!" In all cases where it is at all possible, the pulpit should be provided with a separate supply of pure air: this may, in most cases, easily be effected. The air should reach the interior of the pulpit by a double box, as it were, with the inside perforated with holes, as shown in the figure by the thick dotted lines.



In order to enable the reader to have a distinct idea of the arrangements for ventilating churches, we give two outline sketches of a church. The view in Fig. 1 is a transverse vertical section: *b b* are the fresh-air apertures cut in the walls, and the basement which supports the floor; *b′ b′* the entrance in the passages; *c* the ventiduct for the exit of the foul air; *d* the top. Fig. 2 is a plan of half of the floor and ceiling: the same letters refer to this as in Fig. 1.

The ventilation of hospitals is of the utmost importance. "Imperfectly ventilated, they have in some cases proved a curse instead of a blessing to the miserable patients who have been conveyed to them. That public establishments are known to the medical profession, where, at one time, from the same cause, no case of compound fracture ever recovered; few or none survived the amputation of a limb; mortification attacked every wound, however trivial; while the prostration of strength became so great that men, who at first had stood the severest operations without a murmur, subse-

Fig. 1.

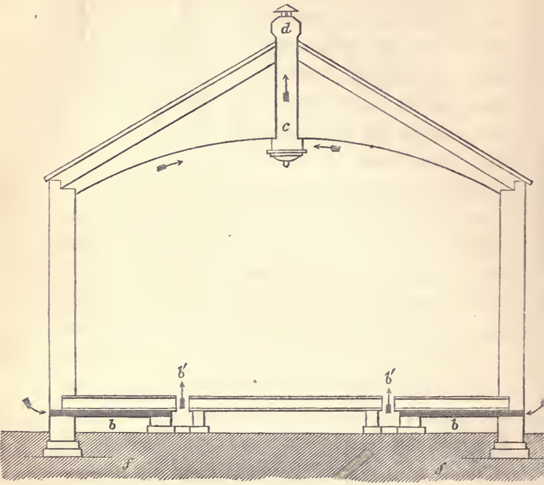
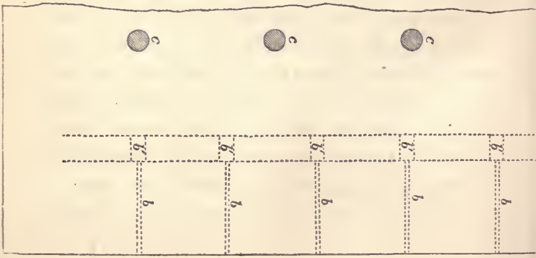


Fig. 2.



quently cried like children from the slightest pain; and that cases have actually presented themselves, where the apparently lifeless corpse, subdued and oppressed far more by the atmosphere with which it was surrounded, than by the disease to which it was supposed to have fallen a victim, has actually been known to revive after removal to the dead-room—a separate apartment, where the play of a wholesome atmosphere, flowing unrestrictedly upon it, revived the fading flame of life, after it was to all appearance gone, and where health and strength were ultimately restored." In ventilating hospitals, particular care should be taken to provide a large supply of fresh air. From the various fœtid exhalations to be met with in such places, the quantity supplied should exceed that allowed for churches. We consider that 6 or 8 cubic feet per minute, for each individual, would not be too large a proportion. The ventilating tubes should be distributed in greater number than in churches, and they should be made all of the same height. In some cases, where there are stories ranged one above another, the foul-air ventiducts cannot be passed through the roof, as is done in churches. Apertures can, however, be made in the cornice, leading to air channels, all of which may be led into one large ventiduct situated in the roof of the building, or leading directly (by tubes inserted in the walls) to the eaves below the outside cornice.

In leading the air thus away, the great desideratum is to keep it collected as much as possible —not to allow it to spread into crevices or empty spaces. Fresh air should be let into ventiducts formed beneath the floor—the apertures for these made in the outside walls, beneath the windows. As birds are often found to build their nests in these holes, bars should be fixed across the openings, or plates of zinc with very large holes, say inch or inch-and-half. The gratings made in the flooring should be in the space between the rows of beds, and diffused, in its entrance to the room, as much as possible, by finely perforated zinc, or sheets of horse-hair cloth. It is of great importance to have means provided for heating the air admitted to hospitals. In Chapter V. the most simple plan for effecting this will be shown. The water-closets should, in all cases, have separate ventilating arrangements.

The ventilation of schools is likewise of great importance. How often do we see the efforts, alike of teachers and taught, paralysed by the atmosphere with which they are surrounded! In cases where there is no other apartment above the school-room, the same plans we have elucidated in the case of churches can be carried into effect; if not, the plans described in Chapter III. should be adopted. One plan we have adopted with great success, where the fresh-air ventiducts could not be led into the interior of the apartment, to be there diffused. We caused large apertures, the size of which were proportioned to the number of youths in the school, to be cut in the external walls, right through to the apartment: the bottoms of these were flush with the level of the floor. Before each of these apertures we made a circular valve, of tin, with an iron handle to open and shut them—much on the principle of the throttle-valve of a steam-engine; and before these again we placed neatly designed boxes, made of wood, the front of which, between the base and the cornice, was formed of a plate of very finely perforated zinc. The foul-air ventiduct was in the centre of the room, leading through the space between the ceiling and the roof. The edges of the ventiduct in the ceiling of the apartment were ornamented with handsome scroll-work, made of stucco; and about 18 inches beneath the aperture was suspended, by beautifully wrought gilt chains, an exceedingly handsome lamp, the products of combustion of which were at once taken off by the ventiduct, and served another important purpose of materially assisting the ventilation, from the upward current produced by the action of the heated air.

As the plan we have mentioned for admitting air is very inexpensive, inasmuch as ventiducts *beneath* the flooring are not required to be made, and the gratings otherwise necessary dispensed with, we give here ample descriptions of the mode of constructing the valve and boxes. We will suppose the aperture for the admission of fresh air in the wall to be 10 inches diameter. Get a plate of strong tin; cut out of it a circular disc 12 inches in diameter; in the inside of this, cut out a circular hole 10 inches diameter; a flat ring, 2 inches broad, will thus be obtained. Make a hoop of the same metal, 1½ inch deep, and 10 inches in diameter; solder the *edge* of this to the flat ring, in such a way as that the hoop shall stand upright upon it. Cut out a circular disc a little less than 10 inches in diameter, so as to fit easily into the inside of the hoop; on one side of this solder a strip of angular metal, the length of which may be 8 or 9 inches. In the middle of the rim of the hoop, at opposite sides, punch two holes ¼ of an inch in diameter; procure a piece of 8-inch wire, or a little thicker; insert the plate or valve in the inside of the hoop, so as that the holes coincide with the apertures of the angular strip soldered on the surface of the valve; pass the wire down the upper hole through the slip, and the opposite hole in the hoop; hammer the angular strip close down upon the wire, so as to fasten the plate to it. It will be seen that, by turning the wire, the valve may be turned either way: the top of the wire should be bent, so as to coincide with the valve when shut. By punching holes in the outer ring, the valve can be fastened to the wall inside, opposite the aperture. The box placed before this should be made of wood, and ornamented with a neat base and cornice. The flat part of the front between them should be left out, and its place filled with a sheet of very finely perforated zinc. Of course, the wall to which this box is fastened forms the back, and the floor of the room, on which it rests, the bottom; so that there are only sides, top, and part of the front, made of wood. The handle of the valve should pass up through the top of the box, and bent, so that, when the valve is shut, the bent part lies parallel with the wall. When it is turned at right angles to it, the valve will be open. An index-plate, made of a half-circular form, may be divided into parts, by which the amount of opening of the valve can be easily ascertained. The diameter of this index-plate would be parallel to the line of wall, and the mark "Open" would be placed at the extremity of its shortest diameter. These valves are exceedingly useful in cases where the air cannot be led beneath the floor to the interior of the apartment.

In ventilating Theatres, it is of importance to remember that "much motion in the central parts would increase the difficulty of hearing." The ventiducts for leading the foul air from the interior should be made near the sides—as behind the rows of seats in the boxes, &c.; the ventiducts being *within* the walls, or placed outside, and covered with ornamental boxes. The ventilator in the centre, beneath the large chandelier, should not be too large, and its area rendered greater or less by means of a nicely regulated valve. The galleries should be ventilated by having fresh-air ventiducts proceeding at once from the walls situated at their elevation. These can be easily made, as the galleries generally are at the highest part of the house. The foul-air ventiducts should be led at once through the roof to the external air, in the same manner as we have recommended for churches. The pit should be supplied with fresh air by minute apertures made in the flooring, or by long gratings, some five or six inches broad, stretching the whole breadth of the pit—below, say, every second seat. Means should be provided for heating the air in winter. The boxes should have independent supplies of air. This can be easily effected by making apertures in the walls, and leading the air at once to the passages, and to the front of the boxes—similar to the plan we have already described for supplying the interiors of pulpits with an independent supply. The stage should be ventilated by a foul-air ventiduct, placed at the extreme back, having at various altitudes, (say the middle, near the top, and the extreme top,) valves easily commanded, opening inwards; through which, when necessary, the products of combustible matter used for scenic effect can find their way, and be led off at once to the external air. In the roof, right above the stage, a ventiduct should be placed, and put under proper control. By the adoption of these suggestions, the details of which will vary according to local circumstances, the interior of a theatre may be easily and efficiently ventilated.

In carrying out plans for the ventilation of public buildings, there is one thing which should be carefully considered—that is, the management of the lights. We have already shown that air is múch deteriorated by the products of combustion; it is necessary, then, to make ample provision for carrying off the products as fast as generated. In our rules for finding the area of the foul-air apertures, we have shown that this cause of deterioration has been provided for; and in cases where our suggestions are carefully carried out, we have no doubt but that the products of combustion will be rapidly carried off. If, however, expense is no consideration, we would recommend the adoption of "exclusive lighting." This may be explained as plans by which the light is confined within a transparent cover, as a pendant suspended from the roof—having no connexion with the interior air of the building, but supplied with air necessary for supporting the combustion from the external atmosphere, the products being at once led off to the outer air by means of a ventiduct. Practically, it will be sufficient to have the light draw its supply of air from the interior of the apartment to be lighted, the foul air being led off to the ventiduct. Such a light as the "Bude" would not only illuminate an apartment efficiently, but likewise materially assist the ventilation. This subject will be returned to in Chapter III., where further suggestions on this important subject will be given.

In noticing the *various* plans promulgated for the ventilation of public buildings, we would be led into the consideration of a vast number of details, the explanation of which would only take up space, and be somewhat foreign to the scope of this treatise, which endeavours to elucidate only what may be easily rendered practicable. While simply referring the reader to study the various details of the plans put in operation for the ventilation of the Houses of Parliament by Dr D. B. Reid—in the perusal of which he will pick up much information that will be extremely valuable—we will content ourselves by explaining the process of ventilating buildings by a peculiar fan, recommended by Dr Arnot, a gentleman who has devoted much of his time to the consideration of the subject; and the recently patented plan of Dr Chowne, the simplicity of which is its greatest recommendation. Dr Arnot's ventilating apparatus may be briefly described as an air-pump, provided with cloth valves and a piston, which may be easily wrought by a boy, or by the operation of a falling weight. This apparatus may be fixed in the lobby or corridor of the church, taking care to supply this part abundantly with air, and the air forced into the interior through the doors, &c. There is no doubt that, with properly constructed foul-air ventiducts, this contrivance is very efficient. In some cases, where it is difficult to provide fresh-air ventiducts, such as we have recommended previously, this apparatus may be used with advantage; but it must be remembered, that it will not give satisfaction unless foul-air ventiducts are supplied and properly constructed. Those who may wish to receive further information about it, may obtain such by applying to Mr Edwards, 42 Poland Street, Oxford Street; and Mr Davies, of 24 Upper Cleveland Street, London, who make the valves to order. The plan patented by Dr Chowne will now be briefly noticed; and, for this, we give the following extract from the *London Literary Gazette*:—" The improvements are based upon an action in the syphon which had not previously attracted the notice of any experimenter—viz., that, if fixed with legs of unequal length, the air rushes into the shorter leg, and circulates up, and discharges itself from the longer leg. It is easy to see how readily this can be applied to any chamber, in order to purify its atmosphere. Let the orifice of the shorter leg be disposed where it can receive the current, and lead it into the chimney, (in mines into the shafts,) so as to convert that chimney or shaft into the longer leg, and you have at once the circulation complete. . . . The curiosity of this discovery is, that air in a syphon reverses the action of water or other liquid which enters, and descends or moves down the longer leg, and rises up in the shorter leg. This is now a demonstrable fact. . . . That air in the bent tube is not to the surrounding atmosphere as water or any heavier body, is (from the result of this discovery) evident; and it must be from this relation that the up-draft in the longer leg is caused, and constant circulation and withdrawal of polluted gases carried on." The action of an inverted syphon *is such* as is here described. We have experimented with a tube so small as half an inch in diameter, and the heated air was drawn down the short leg, ascending by the long, with considerable velocity. If acting with certainty on a large scale, we hail the invention as one of the most important of the day; so simple in its nature, so easy in its application, it really is a boon to the community. The phenomena exhibited, however, by this invention, have been observed and commented upon many years ago. Desaguliers described a smoke-consuming stove, consisting of a fire in the short leg of a syphon, the long leg drawing the smoke down through the burning coals, and up the long leg. Dr Franklin says, "Such a machine is a kind of inverted syphon; and as the greater weight of water in the longer leg of a common syphon, in descending, is accompanied by an ascent of the same fluid in the shorter, so in this inverted syphon the greater quantity of levity of air in the longer leg in rising, is accompanied by the descent of air in the shorter." The plan is, however, in direct opposition to that recommended by Tredgold. We will notice this more fully in the succeeding chapter, concluding our remarks by again quoting from the same writer above, in connexion with this important discovery:—"We see no end to its application. There is no sanitary measure suggested to which it may not form a most beneficial adjunct. There is not a hovel, a cellar, a crypt, or a black coal-hole anywhere that it may not cleanse and disinfect. We trust that no time will be lost in bringing it to the public test on a large scale; and we foresee no impediment to its being immediately and universally adopted for the public weal. We ought to remark, that fired or heating apparatus are not at all necessary; and that, as the specification expresses it, 'this action is not prevented by making the shorter leg hot while the longer leg remains cold, and no artificial heat is necessary to the longer leg of the air-syphon to cause this action to take place. Extraordinary as this may appear, we have witnessed the experiments made in various ways, with tubes from less than an inch to nearly a foot in diameter, and we can vouch for the fact being perfectly demonstrated. Light gas does descend the shorter leg when heated, and ascends the longer leg where the column of air is much colder and heavier." In applying this invention to the ventilation of public buildings—for instance, a church—due care should be taken to supply the interior with a sufficiency of pure air—for the principle we formerly enunciated, relative to the withdrawal of foul, will apply in this case as in all others. The short leg of the syphons should be placed at intervals in the walls, in the ceiling above the side aisles of the church, immediately beneath the galleries, and also above the galleries—the wooden ventiducts we have formerly explained being placed in the main ceiling above the body of the church. The rules for ascertaining the area of the apertures of the syphon tubes will be the same as we have already given—so much of the whole amount required being allotted to these, and the remainder to the ventiducts in the main ceiling. In buildings already constructed, enclosing the legs of the syphons in the walls would be attended with considerable expense; they can be fastened to the exterior, and concealed with ornamental coverings. Before putting this plan into effect, liberty to adopt it must be granted by the patentee—his discovery being protected by letters-patent.

Architects will easily perceive, that, by the adoption of the plans we have recommended, not only will buildings be effectually ventilated, but in a great measure, if not altogether, dry-rot in the timbers will be prevented, by the free circulation of air in the lower part of the building — a desideratum of considerable importance. And, in planning new constructions, we would earnestly recommend them to adopt, from the very first, efficient contrivances for securing ventilation. Architects have much in their power; and we humbly conceive that, when fully aware of the importance of the subject, they will not be apathetic or indifferent to the application of simple, effectual plans.

In regulating the operation of ventilation effected by simple openings, provided with valves, such as we have described, the attendant should pay attention to the number of people assembled in the interior of the building, and so open or shut the valves accordingly—as it is evident that the same area of aperture will not be required for five hundred people as for a thousand. The index-tables we have figured and described, will be of service in enabling him to adjust the valves; they may be attached to the fresh-air ventiducts as well as to the foul. If he calculates the church to be half full, he will put the balance index-weights at the mark "half" in the table, and so on in proportion; and he should make a little allowance in the day-time, by shutting slightly the valves, as the lights are not in use. It is to be observed, that the whole area of the apertures fixed by the rule we have given, applies to the maximum number the building is to contain. The fresh-air ventiducts should be shut or opened in the same proportion as the foul air. Attention to these rules is necessary, as, supposing half of the congregation only was assembled, if the ventiducts were wholly opened, in all probability there would be a descending current coming down one side of the foul-air tube, and an ascending current at the other, the area being too great for the body of air to pass through it. By a little experience the attendant will soon be enabled to regulate the ventilation with considerable precision.

CHAPTER III.

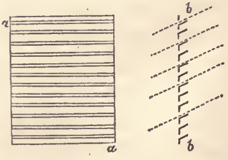
VENTILATION OF APARTMENTS IN DWELLING-HOUSES, SHOPS, &c.

"I praise the man who builds
High on the breezy ridge, whose lofty sides
The ethereal deep with endless billows chafes.
His purer mansion, nor contagious years
Shall reach, nor deadly putrid airs annoy."

ARMSTRONG.

THIS part of the subject has been unfortunately invested with many apparent difficulties, arising, doubtless, from the promulgation of so many different plans; the details of which, complicated, in appearance at least, however simple in principle, have had the effect rather of deterring the majority of people from attempting the ventilation of their apartments, than inciting them to the attainment of information in connexion with the subject, and, of course, a desire to be supplied with efficient means to secure good ventiliation. This is the more to be regretted, as it is a matter of no small importance that there should be a large quantity of air supplied to the interior of the apartments in which individuals habitually reside. Important as is the ventilation of public buildings, compared with that of dwelling-houses it is of little moment; it is only at intervals that people assemble in *large* numbers—in their own dwelling-houses they are constantly exposed to the atmosphere therein, which, in nine cases out of ten, is foul and impure, and in consequence the cause of much illness and disease. In treating of this subject, we will endeavour, as far as possible, to divest it of all its difficulties, and explain, briefly and practically, the simplest modes of ventilating apartments.

The first thing to be considered is the supply of pure air; and particular attention should be paid to the source from whence it is derived. Too frequently, in consequence of the defective condition of drains and sewers, the air around our dwelling-houses is very much contaminated. If such destroyers of the purity of the fresh air should be situated near the house to be ventilated, the air should be drawn at the greatest possible distance from them. In supplying houses with air, there are two modes by which it may be effected—by supplying the lobby, hall, or central staircase with a large amount, or each separate apartment with a quantity sufficient for its size. In all cases where the architectural arrangements will admit of it, we would recommend the latter mode to be adopted; by the former, from the multiplicity of currents, produced by the doors and windows having connexion with the central staircase, &c., the risk will be run of one room taking a larger supply than another, thus depriving one of its proper quantity. That this may be the case is likely, when we consider that a drawing-room, for instance, might draw its supply from a contiguous apartment, the egress being easier than from the hall: in very large mansions, however, the first mode may be easiest adopted. We will first consider the mode of supplying each room, independently of the others. Let an aperture of sufficient size (calculated according to the mode given in Chapter II.) be made in the outside wall, beneath the window. To preserve a neat appearance, the area required may be divided into several parts, and corresponding apertures made in the wall—the neatest form will be an oblong, somewhere about six inches long, by one and a half broad. These apertures should be covered, on the outside, by plates of perforated zinc. From where these apertures communicate with the interior of the apartment, let the skirting board be pierced with numerous small holes, and the inside of these covered with perforated zinc, or hair-cloth, or left open, as when bored with a gimlet. Instead of admitting the air at the skirting board, it may be led to the centre of the apartment, where the table stands, the floor being pierced with holes to permit its egress: the carpet of the room would serve to diffuse it. Again, it may be led to the wall opposite the fire-place, and admitted by apertures in the skirting-board. In cases where the building is being planned, the architect should incorporate ventiducts in the interior of the walls, leading from the outside, below the eaves or bottom of the cornice or coping, as shown in the figure in Chapter II. In cases where these modes of admitting air are not available, the plan which we will now describe should be adopted. The sheets of perforated zinc used by J. Toynbee, Esq. and by the Samaritan Fund, are cheap and simple. The pane of glass farthest from the fire-place, and in the upper row, is taken out, and its place supplied with a sheet of zinc, having two hundred and twenty perforations to the square inch. Panes of perforated *glass* are now made for this purpose—they may be obtained from Mr Bowie, No. 1, Fowkes Buildings, Tower Street, City, London. The glass louvres, patented by Bailley, are exceedingly handsome, not very expensive, and thoroughly efficient. We here give a description of a plan for making tin louvres or window ventilators. Take a sheet of tin, the size of the pane of glass

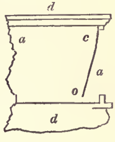


to be removed; cut long apertures, as shown in the sketch, at *a*, of length very nearly equal to the breadth of the plate, and quarter of an inch broad; to the *bottom* side of these slits, which should be three-eighths of an inch apart, solder strips of tin, the length of the aperture, and three-eighths or half an inch broad, inclining upwards, as seen at *b b*. According as the wind or air is required to be thrown into the room upwards or downwards, so should the tin-plate be inserted in the frame, with its louvres inclined accordingly. In the sketch it is shown as fixed to throw the air upwards, the dotted lines showing the course of the air.

In supplying fresh air to the lobbies, halls, or central staircases of large mansions, from which all the apartments are to be supplied, care should be taken to have the quantity sufficient in volume. It will materially assist the ventilation if the air is warmed as it is admitted; in Chapter V. we will show how easily this may be effected. The air should be led to the floor of the hall, in which apertures may be made to allow it to pass through; or it may be taken to the back of the skirting, or beneath permanently fixed tables, the fronts of which should have plates of perforated zinc. If the staircase is provided with a skylight, this should be kept carefully closed; the desideratum, in such cases as we are now considering, being, to supply each apartment with means of withdrawing the used air, so as to draw their supply of pure air from the central magazine; not only ventilating themselves, but also the staircases, passages, &c., these being supplied with fresh air from the central magazine. If the skylight was left open, thus creating a powerful upward current, the flow of air into the apartments would be materially retarded, if not in some cases altogether stopped. In some instances the withdrawal of the foul air has been recommended to be effected by the skylight, or an opening in a similar position. Now the obvious effect of this arrangement would be, we opine, a constant struggle, if we may so express it, between the currents of fresh air endeavouring to obtain admission to the apartments, and the stronger upward current of air produced by the great opening above, pulling them backwards. Doubtless, the currents of fresh air would be at the lower part of the doors, &c. of the apartments, while those of the foul would be at the top—thus, certainly, separated; still, as we have before said, the natural flow of the fresh air currents would, in such a case, be materially retarded. In our way of thinking, taking away from a magazine of air, as fast nearly as it is introduced, is scarcely the most effectual mode of keeping the supply constantly at its maximum; fresh air is introduced to supply the apartments connected with such a magazine, and it should alone be used for such a purpose. The skylight or other opening is not required to ventilate the staircases, &c., as may be affirmed, it being obvious that such will be effected by the apartments connected with them—these being supplied with ventilating arrangements for withdrawing air, by which a constant current will be kept up—the rooms drawing their supply from the central magazine in the staircase, hall, or lobby, as it may be; while it, in its turn, draws its own supply from the external air through the openings provided for it.

There is one danger connected with this plan of supplying air to the apartments of large mansions, worth being noticed; this is, if each apartment is not properly ventilated, the foul air from it will obtain access to the central magazine whenever the door is opened, its egress through such being easier—the air in the central magazine being thus contaminated. Again, some apartments may, from more powerful ventilating arrangements, draw their supply from another apartment; this shows the necessity of having the supply to the central magazine ample. If the mansion consists of many stories, each landing may be supplied with a separate supply of pure air, independent of the openings in the hall previously mentioned. This may be effected by making apertures in the outward wall at such places; indeed, it would be well for every passage or corridor to have thus an independent supply. The openings for admitting the fresh air to the apartments should be near the floor, behind the skirting—which should have perforated zinc, or the wood pierced with numerous small holes; or it may be led to the centre of the apartment, as formerly noticed. Of the two modes of supplying air to the interior of apartments, we think that we have shown enough to prove the superior merits, where attainable, of the plan of supplying each apartment, independently of the others. Rooms thus managed will act well, they will draw in as much air only as they require, and be subject to no opposing influences. Of course, in this mode, the staircases will require to be ventilated separately, the fresh air being supplied at the lobby, and the foul air extracted or withdrawn by an opening at, or near, the skylight. Care should be taken to have this upward current gentle and easy.

The next operation we have to consider is the withdrawal of the used air from apartments, to which the plans we have recommended for applying fresh air have been applied. A valve for this purpose, highly recommended by J. Toynbee, Esq., and very efficient when properly adjusted, may be used. It is a simple modification of Dr Arnot's plan, which we may term the "suspension valve." Mr Toynbee describes it as follows,—"It consists of a square iron tube, of from three to six inches diameter, and so long that the outer orifice should be flush with the wall of the apartment, and the inner one enter the chimney. These tubes are usually from four to six inches in length. At the orifice entering the room, there is either a plate of perforated zinc, or a piece of fine wirework, from the upper and back part of which hangs a piece of ordinary or oiled silk, which acts as a valve, so as to allow the warm and vitiated air to pass up the chimney, and prevent any smoke from entering the chamber. The accompanying figure will give a good idea of this valve: *a a* is the iron box, *c o* the flap of silk, *d d* the wall of the apartment. The cost of the valve, including the fitting up, is 3s. Of



the efficiency of these valves, Mr Toynbee makes the following statement,—"The effect on the health of the patient, I have observed, is to accelerate the cure, and to alleviate the symptoms, so as to give great comfort to the patient. The people remark that the ventilation has carried away the smells, and purified the place. I am now continually applied to, by the friends of those whose rooms have been ventilated, to bestow upon them a similar boon."

And here we would direct attention to a fund which has been the means of doing good to a considerable extent, amongst the poor classes of two parishes in London—we allude to the Samaritan fund in connexion with the St George's and St James' dispensaries, which was established for the purpose of supplying the sick poor with flannels and nutritious food, and for *ventilating their apartments*. In the latter way, the committee have declared it to be their opinion that ventilation is one of the most important curative means. We trust that this institution will have many imitators throughout the kingdom. Those wishing for further information, in connexion with its management and operation, by writing to Joseph Toynbee, Esq., the honorary secretary, 60 King Street, Golden Square, will, we have no doubt, be supplied with every necessary particular.

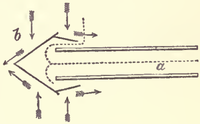
A modification of the suspension valve is made with metal valves, very nicely suspended, and movable with the slightest current. We have hung them so delicately, that the valve has been moved by a breath so faint, that the only indication of our having breathed at all was by the movement of the valve, and the condensation of the breath on the polished brass front. They are made in a very superior style by Mr Edwards, Poland Street, costing from 7s. 6d. upwards; they are also made in various styles by J. Allen, 22 Guildford Street, Wilmington Square, London. In fixing them, great care should be taken to suspend the valves accurately, as, if this is not attended to, smoke is apt to come into the room. In some instances, the upward current in the chimney is not sufficient to open the valve; but by adopting the plan of supplying fire-places with air, as explained hereafter in Chapter V., they will act sufficiently in all cases.

Tredgold gives an explanation of a plan by which the foul air may be withdrawn from the interior of apartments; we give it here: "If an inverted syphon be placed with one leg in the chimney, so near to the fire that the air in that leg will be warmer than the air in the other leg, motion will take place; for the air will ascend in the warm leg and go up the chimney, and a descending current in the cool leg will take the air from the room. To render the application of this principle successful, the mouth of the tube should be at the ceiling of the apartment; the lowest part of the curve should be, as much as convenient, below the point where the heat is applied; and the aperture through which the air flows into the chimney should be formed, so that the soot may not fall down the tube: also the mouth should have a register to close it, or regulate the ventilation. Such a tube may be easily placed in the angle of the chimney breast, or let into the wall. The branch or leg which goes up the chimney should be brought so near to the fuel of the grate as to receive a considerable portion of heat." Of this *proposed* remedy Mr Tredgold says,—"I have little doubt it will be in a great measure effective."

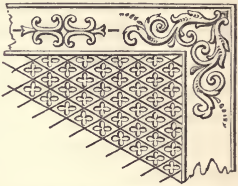
The new mode of ventilating apartments, patented by Dr Chowne, formerly described in Chapter II., is in direct opposition to this plan of Tredgold's. The only effect of such would be the drawing of the smoke from the chimney down the short leg, and into the room through the long one—

a process by no means desirable. If the reader will turn to Chapter II., where we described this plan, he will see that, however much the short leg was heated, the ascending current in the long one would still continue. From the conclusive experiments which have been made, and from the fact that the principle has been successfully applied in the ventilation of buildings, we would recommend, in cases where it can be adopted, a trial of Dr Chowne's patent.

As an efficient modification of Dr Arnot's principle, we would recommend the adoption of the following plan. There is considerable difficulty frequently to place the suspension valve correctly, and, unless well adjusted, the smoke is apt to come into the room. With this, however, no one can have the slightest difficulty in the adjustment, and no smoke can possibly enter the room through it. Make a hole in the wall of the apartment, six inches beneath the cornice above the fire place—this should be of size proportioned to the capacity of the room; measure from the outer edge of the aperture to a point as near as possible in the centre of the chimney flue; make a tin tube, as represented at *a*, of this length, and put a cover *b* in the end, which is to be in the chimney; pass this through the aperture, which, of course, must be made large enough to admit the cover; when the edge of the tube is flush with that of the aperture in the wall, solder a plate of plain or ornamented brass, with a flange, to the edge of the tin tube, very tightly: the flange should be of breadth sufficient to cover the vacant space of the aperture in the wall, (caused by the difference of size between it and the tin tube,) by at least one inch—the central aperture of the flange being equal in diameter to that of the tin tube; Roman cement should then be applied all round the edges of the flange, in order to make the passage to the chimney only through the interior of the tin tube. The outside edge of the flange should be surrounded with a neat scroll-border of stucco; to mask the entrance to the tube, an ornamented wire-grating might be fastened before it: thus ornamented, the ventilator would present no unsightly appearance. The dotted lines in the figure show the current of used air drawn from the apartment,



by the ascending current in the chimney. In the event of smoke being driven down the chimney, it cannot possibly enter the tube, as (the course of the arrows showing such) it will be deflected from the openings by the angular coverings attached; moreover, by adopting the plan shown in Chapter V. the occurrence of down draughts in the chimney will be effectually prevented. (See Recapitulatory Remarks, at the end of Chapter V.) The annexed figure will show how highly ornamental to the general arrangements of a room, the apertures of ventilators may be made. The ventilators we have described for extracting the used air from apartments, will act most efficiently when there is a fire in the chimney with which they communicate. This, however,

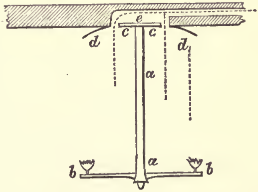


will not be the case in summer, when ventilation is required very much. If, however, the supply of fresh air is properly managed, all that is necessary to do is to open the valves of the suspension-valve ventilators, and a current of air upwards will soon be established in the chimneys—such being in summer foul-air ventiducts alone; in winter, ventiducts both for smoke and foul air. The tube we have described will act in all cases without any alteration. Dr Chowne's ventilators will also act in summer equally as in winter.

An architect of some note communicated to the author a plan for ventilating apartments, which he had applied to gentlemen's villas with some success. It must, however, be incorporated with the building when first constructed. At the ceiling of the apartment, above the cornice, he makes a narrow opening; this communicates with a channel formed between the lath and plaster, and the beams in which the laths are nailed. The foul air is led through these to apertures formed on the outside walls beneath the eaves, thus affording for it a clear escape from the room. The fresh air is admitted by openings made in the skirting of the room, or in the floor—in the latter case, the carpet covers the apertures, and serves to diffuse the air. In this plan, each room must have one independent channel for the egress of the foul air. There are some practical difficulties connected with this plan, which will militate against its general adoption; however, with an ample supply of fresh air, there is no doubt that it will in a great measure be effectual.

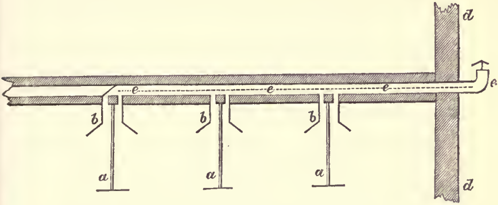
In private apartments, the management of the lights is of great importance. In cases where gas is used, the products of combustion should at once be led off; where candles and table-lamps are chiefly used, the products will be carried off by the ventilation; but all fixed lights, suspended invariably beneath a certain portion of the ceiling, should have means by which their products are instantly removed. "In considering," says Dr Reid, "the influence of the products of combustion formed during artificial illumination, even where no peculiar impurity is presented, it will be noticed that they are as destructive and offensive to animal life as those formed by ordinary fires. It is desirable, accordingly, to discharge them by a chimney or some other means, in the same manner as those from the common fire. But where the amount of illumination is small, and *the apartment is otherwise ventilated*, the amount of moisture and carbonic acid may be too trifling to render this necessary. . . Gas, when pure, does not evolve, during combustion, products that are more offensive than wax, tallow, or oil; but, from its economy as an illuminating power, a large amount of it is in general used where it is introduced as a substitute for other lights. Further, all rooms lighted with gas, where special arrangements are not introduced for ventilation, are subject to the evolution of minute portions of unconsumed gas. . . . Another peculiarity connected with gas lights, burning in ordinary apartments, requires special attention—viz., their extreme tenacity of combustion. Gas lights burn for a considerable time in atmospheres so loaded with carbonic acid, moisture, and nitrogen, as to extinguish oil-lamps and candles, or to render their combustion extremely feeble: they do not, therefore, so promptly indicate a gradually deteriorating atmosphere. The nature of the gas-burner used also affects the duration of the flame in the vitiated air. The reason of this peculiarity in gas is abundantly obvious, on considering that an ordinary gas-lamp is provided with gas already formed, by the action of heat; whereas oil, wax, and tallow, require heat for the production of the gas beyond what may be necessary for its combustion. . . . All vitiated air from oil-lamps or other lights, if not constrained in its movements by any local current, passes directly towards the ceiling of the apartment in which they are placed; recoiling or descending from it as successive portions of warmer air displace it, and as it is subsequently involved in streams of fresh air passing from doors or windows to an open fire. Accordingly, all air above the level of the discharge may be intolerable, and loaded with the products of combustion, while a less impure atmosphere prevails below."

When a candle or single lamp is used in a well-ventilated apartment, the products diffused through the atmosphere above them will be led off by the ventilators. This may also be the case with gas lustres or chandeliers suspended, as is usually the case, from the centre of the ceiling; but it is important that these, especially when much light is obtained from them, should be provided with separate foul-air ventiducts, "as much heat is developed, and the radiant heat which they emit is of considerable amount, even though the products of combustion be carried away." The annexed figure will

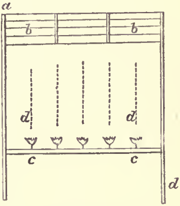


explain a simple method of carrying away the products:—*a* is the main tube of the chandelier; *b b* the jets; *c c* the circular ornament; *d d* the cap by which the heated air is caught and deflected into the tube *e e.* This tube may be led between the ceiling at once to the chimney in an independent air channel; or, to save expense, it may be led along the outside of the ceiling, and ornamented as it stretches across the roof to the chimney. The cap *d d* may be made highly ornamental—a handsome addition to the decorations of a room, rather than an unsightly object—the clamshell might be designed as one.

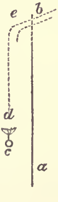
In shops, the adoption of means for withdrawing the products of lamps has met with great success—"silversmiths find that these tubes prevent their plate from tarnishing; silk-mercers their goods from fading; ironmongers and cutlers their wares from rusting." These tubes "ought to be universally adopted, and above all, no bakers, butchers, grocers, or provision dealers, should be without them." We give here an illustration of a simple inexpensive kind, which may be fitted up in every shop with advantage. If there is no air-flue to which the products can be led, the tube from all the lights may be led along the ceiling to an aperture in the outer wall, at the front or back of the shop: if in the front, the aperture should be covered with an ornamented grating; if at the back, a cowl or cover, as shown in the cut, may be used with decided advantage: *a a a* are the gas lights; *b b b* the caps or covers; *c c* the flue or tube; *d d* the wall; *e* the cap or cowl; the dotted lines show the course of the currents. The lights used in the illumination



of shop windows produce much air that acts very deleteriously on the goods exposed for show. The annexed sketches will explain how this may be obviated:—At the upper row, in the window, have Baillie's transparent glass ventilators fixed in each pane; from the head of the frame *a a*, have an angular board ornamented on the under side, sloping downwards, as shown at *e*;



c c represents the tube from which the jets *d d* are supplied with gas; *b b* the glass ventilators; the dotted lines show the course of the currents; the heated air striking upon the board *e* is deflected upwards, and is passed out through the spaces of the ventilators. The board should be of sufficient breadth to reach



beyond the line of gas jets, at least four or six inches; and, if made of a neat design, it will rather be ornamental than otherwise. It might also be made curved, and its lower edge neatly carved, or supplied with small Gothic pendants, which would add much to the decorative appearance of the window. (See Recapitulatory Remarks.)

In ventilating workshops in which there is a central stove, a supply of air, independent of that for the rest of the apartment, should be given to it; and the tube from which (by which the smoke and heated air is carried away) should be led through the ventiduct placed in the roof of the apartment, if the arrangements of the structure will admit of it. In some shops, stoves are used both summer and winter, thus affording a great help to the ventilation at all times. The gas lights should all be provided with tubes to lead off, at will, the products of combustion. The plans we have explained can be made available, in almost every case, at a very moderate outlay. As in many cases the poorer classes shut up the ventilators, impressed with the absurd idea that they are dangerous, William Hosking, Esq., proposes the following plan, which cannot fail to be effectual: "A sweet air flue should be made within the outermost jamb of every chimney breast, from the bottom to the top, and opening into the outer air—free from all communication with the smoke flues, and not liable to be contaminated by them. This should open out at the lowest level again—either directly under the floor, or by a horizontal flue with a grated mouth—so that it may be fed with air from both ends. Ninety-nine out of a hundred would never suspect the mode of access of the outer air, and they would breathe fresh air in spite of themselves." Mr Hosking conceives that the current of air, produced by the air flowing up the chimney, will create currents from all parts of the room—thus freeing it from the foul air. Now, we by no means agree with him in this view of the matter; it is contrary to general experience. If it was correct, we would find all apartments well ventilated in which common grate fires were in operation. This is not found to be the case, the fires invariably drawing their supply from below—scarcely, if ever, exerting an influence above the zone of respiration. And that such is the case is fortunate; if not, one bad effect would be the drawing of the current of foul air past those sitting round the fire-place. In adopting, then, this grate of Mr Hosking's, let a ventilator, such as we have previously described, be applied. In Chapter V. we will give a plan and description of a method similar in principle to that of Mr Hosking's.

In ventilating apartments, great attention should be paid to that of the bedrooms. On this subject Sir James Clarke remarks,—" Nothing, indeed, can be constructed on a worse principle than the bedrooms in this country generally are. Their small size and their lowness render them very insalubrious, unless well ventilated; and the case is rendered worse by the close windows and by the thick curtains with which the beds are so carefully surrounded, as if to prevent the possibility of the air being renewed. The consequence is that the occupants are breathing vitiated air during the greater part of the night—that is, during almost one half of their lives." In such cases, it may well be said, "that the atmosphere in the morning smells more like that of a charnel-house, than an apartment fit for the repose of human beings." We would earnestly recommend means of ventilation to be carefully attended to: if people will not go to the expense of the arrangements mentioned, let them, while absent in the day, have the windows opened, and at night a small portion of the upper sash, say 4 or 6 inches, let down. To diffuse the air thus let in, a plate of perforated zinc 8 or 9 inches broad, and length sufficient to stretch across the window, may be easily attached every evening. Care should be taken that the window thus opened should not be situated right above the bed. Thick curtains should not be used. If the housewife thinks these unwholesome appendages absolutely necessary, let her adopt them of open gauze or net: if a bird suspended in its cage at the top of a bed, within close curtains, is killed by the foul air collected there, it cannot be healthy to allow the same to act upon the human frame.

Having thus briefly described efficacious and easily attainable modes of ventilating apartments, independently of all casual means, we would, in conclusion, recommend every one, in addition to the adoption of these, to ventilate the apartments by opening, on every possible occasion, their doors and windows. Too large a supply cannot be obtained. The currents produced by such are health-giving and health-restoring draughts. There is much nonsense promulgated about the danger of draughts. We have many a long summer day sat in a draught, so thorough and strong that our papers had to be retained on the table by books or weights, or they would have been blown away; and throughout the whole of the cold months of this confessedly severe winter, we have sat for hours writing, in a draught sufficient to cause a very considerable deflection of the flame of the candle we used in the evenings; and we will venture to say that no one has enjoyed so singular an immunity from colds as ourselves, although (the air admitted not being diffusively warmed, save through the local action of the fire) the extremities farthest from the fire were on many occasions perfectly benumbed with cold, such being the rapidity of the current of cold air; yet we have not had the slightest vestige of a cold. Even now, as we write, we can feel the pure fresh air perceptibly passing us; and we hail it as a boon, knowing that it is the very principle upon which our healthy existence depends. Many, very many, are in the habit, moreover, of exposing themselves similarly without incurring any colds, &c. In India, draughts are the very life of the inhabitants, and are artificially produced. We do not assert that people can all at once subject themselves to the influences of draughts with impunity; with the habit of living in close, confined, over-heated apartments, no wonder that many catch cold on being exposed to a draught. On this Dr Reid says, "The greater the degree to which the movements of the air have been reduced, the more does the system become sensitive to any renewal of its wonted action; and that the best means of obviating these effects, which are so much dreaded, consist in so regulating the movements of air that it shall never be reduced excessively; and thus the system can never be heated up to that point when draughts and cold currents become dangerous as well as offensive." In other words, that, by exposing the body gradually to the influence of healthy currents, in process of time, the system becoming more equally maintained in temper, changes are neither so frequent or so deleterious in their effects. On this subject Dr Reid has further remarks worth notice. He says,—"It would be well for those who suffer from draughts and currents, and who constantly declaim against any movement of air, to consider that their bodies have been so formed that the air never stagnates round them during life; that a slow, but equal and continuous current ever moves round the living frame; that it is not the *mere movement of air* which is the cause of offence, but the movement of air in proportions of a character uncongenial to the condition of the system at the moment; that even the most delicate ladies, who express their horror of draughts and currents, practically increase from time to time the movement of air that infringes upon them in warm atmospheres with their fans, producing an agreeable and refreshing atmosphere with air which is oppressive and offensive, when not assisted by their inordinate movement."

A walk in a gentle breeze often cures a headach, the party little dreaming that the cure was easier obtained—that a window lifted, or a door opened, would have had the same effect, by establishing a thorough current of air through the room, the want of which was in all likelihood the cause of their complaint. Parties are advised to travel for their health, and leave home and all its comforts, submitting to heavy expenses and innumerable discomforts, to obtain that which the expenditure of a few shillings at home would have supplied them with —fresh air. For it cannot be denied that the chief benefit derived from travel, is the almost constant exposure to fresh air, or, as popularly expressed, "the change of air." To people of very delicate constitutions, it would be highly dangerous to submit themselves suddenly to draughts and cold currents; but we are certainly of opinion that the majority of individuals are by far too particular in this respect. But, though advising all to open their doors and windows, we would at the same time earnestly recommend every one, as health is valued, to have a plan of ventilation, independent of all such casual means, instantly carried into effect. Not taking into account the injurious effects of foul air on the body, we cannot conceive, even as a matter of taste, how people should prefer foul and fœtid to the sweet air,

> "That trembling floats from hill to hill,
> From vale to mountain —with incessant change
> Of purest element !"

We will close this part of the subject by expressing a hope that our remarks will tend, in some measure, to direct more particular attention to this important subject of domestic ventilation.

CHAPTER IV.

VENTILATION APPLIED TO AGRICULTURAL STRUCTURES.

—" Each ambrosial breeze
That fans the ever undulating sky,
. . . whose fostering power regales
Man, beast, and all the vegetable reign."
ARMSTRONG.

A PROPER supply of fresh air is as necessary to the health of the inferior animals as it undoubtedly is to man. Baneful as is the influence of impure air, on the constitution of human beings exposed to its influence, it is no less so to the valuable animals the horse and the cow. Many are the diseases which affect our domestic animals, brought on by exposure to foul air; and many a valuable animal is sacrificed to close and ill-ventilated stables and other structures.

Before proceeding to the explanation of plans for ventilating agricultural structures, we will devote a small space to the mentioning of other arrangements, which, though they may be considered as somewhat foreign to our more immediate subject, will be of some use to those having an interest therein.

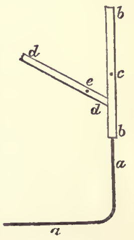
In the construction of a proper stable or cowhouse, we conceive four points are necessary to be considered. These are—1. Sufficiency of space in the stalls. 2. Proper methods of ventilating and heating. 3. Proper drains and reservoirs, by which all exuviæ can at once be carried off (so as not to vitiate the air in the interior,) and in which they may be collected and preserved for manure. 4. A properly arranged series of water-pipes and reservoir, so as to be available for clearing the whole range of stalls, and to provide a supply for the animals' use. Passing over the first as sufficiently obvious—although important to be remembered, and as hereafter to be treated of—we shall give a few hints in connexion with the two last.

We would recommend all the stalls to be made sloping at a certain angle from the head towards the foot. This slope may be one foot in every eight. At the bottom part of the incline, a pipe or covered drain should be placed in front, running along before all the stalls, and should have a considerable fall or incline throughout its whole length, towards a convenient part of the building, where it should communicate with a larger pipe or covered drain, which should lead to a reservoir for liquid manure placed in the back-yard of the building. The liquid manure will flow down these pipes or drains to the reservoir.

As the liquid collected from the stalls forms a very excellent manure, it is of importance that proper methods should be adopted for collecting and preserving it. As a most effectual means, we recommend the power of running water to be used in the following manner: Thefloor of the stall should be made of asphaltum, or be closely flagged, (not floored with small stones, as dirt is exceedingly apt to collect between the interstices.) An iron pipe of the breadth of the stall, and closed at the ends, should be placed at the head of each stall, its under side pierced with small holes, or, what will be better, a slit or small aperture stretching nearly across its whole length. This pipe should communicate with a cistern or reservoir, placed at a level considerably above that of the stalls. The coarse litter and solid manure (when the stalls are wished to be thoroughly cleaned, and the manure in the pipes to be flushed down into the reservoir) being removed, the communication between the pipe at the head of the stall and water cistern is opened, and a thin but powerful stream of water is projected down the inclined plane of the stalls, carrying along with it all impurities, and the manure in the pipes, to the reservoir. If the stream is continued for any length of time, to sweeten the stalls, the accession of water to the contents of the reservoir might deteriorate the manure. To provide a remedy for this, let a pipe or drain be connected with the drain running before the stalls, leading to a cesspool independent of the reservoir. This pipe should be provided with a stop-crane; or other means for shutting off communication, the same should be applied to that leading to the reservoir. By shutting the stop-crane leading to the reservoir, and opening that of the cesspool, the water will run thereto, and *vice versa.* Fig 1.

Fig. 1.

illustrates the incline of the stall and position of drains: *b b* is the stall, *c* the floor of the stable, here represented as formed of small stones; *a* the section of the drain or pipe running before the stalls; *d* the water pipe; *e* the small pipe leading from the water cistern to supply the pipe *d.* We should recommend the cistern containing the water to be placed at the roof of the building. If the source from which the water is to be obtained be at a lower level than that of the roof, the water may be pumped up to the cistern from a supply below. And we would here draw the attention of farmers to the important means for preventing fires thus put in their possession by adopting such a plan as here recommended. For, by leading pipes from the cistern to convenient places in the walls in the interiors of buildings, and finishing them there with screw-cocks, to which leathern or gutta percha hose may be attached when necessary, a powerful stream of water may be directed to any part of the interior required. For application to the exterior, pipes should be led to little square wells cut in the ground at the sides and ends of the building: these should be somewhere about two feet square, and one foot deep and lined with bricks—the end of the pipe projecting up the centre of this well, and provided with a screw-cock, to which the hose may be attached. Trap-doors made of iron or wood may be used to cover these wells when not in use. Any part of the building may be commanded with pipes leading from these. It will be evident, also, that such a plan will be available for the cleaning of windows, &c. without and within—also the floor. For these latter purposes, the nozzle of the hose should be very small, about three-eights of an inch diameter. Moreover, should the building so furnished with a high level cistern be near the *house* and other offices, and at a higher level than these, the supply of water might be made available for the extinguishing of fires there.



The annexed is a diagram illustrative of the mode of managing the flow of water through the exuviæ pipes: *a* is the pipe running before the stalls, leading into the pipe *b b*, which goes to the liquid manure reservoir; there is a stop-crane at *c*; *d d* is a pipe leading to the cesspool or water drain. When the valuable exuviæ are all washed into the reservoir, the stop-crane *c* is shut, and that of *e* opened; the water from the stalls, debarred from flowing to the reservoir, turns off to the cesspool through the pipe *d d*.

In ventilating stables, cow-houses, &c., the supply of air will require to be of larger amount than for buildings where human beings are to assemble. In Chapter II. we have shown that four cubic feet of air is a fair allowance for each individual per minute; now, for horses and cows, it may be assumed that three times as much will be required. The rule, then, for finding the area of foul air ventiducts will be as follows. Multiply the number of horses the stable is to contain by 12, and divide this product by 43 times the square root of the height of the tubes in feet, (that is from the ceiling to the floor,) and the quotient is the area of the ventilation tube or tubes in feet. The fresh air should be admitted by apertures in the walls, and led by tight channels to pits or wells made in the floor, between the outer edge of the stalls and the outside wall. Supposing the size of apertures for fresh air to be six inches square; the pits in the floor should be of depth sufficient that, when the lower edge of the ventiduct is flush with the bottom, the upper edge of the ventiduct should be two inches from the floor: this will make the depth of the pits 8 inches; their breadth may be 15 inches and length 2 feet. They should be covered with gratings. The apertures for fresh air should be made below each window; if possible, the area should be divided to admit of this. Supposing there were six windows, and the area of the fresh air ventiducts required to be six square feet, six openings should be made, each one foot square in area of aperture. It would be better to have the air diffused as much as possible. This might be effected by having a pit made the whole length of the stable, in the middle of the floor, and covered with a grating, below which perforated zinc should be placed. All the apertures should have valves fixed on the outside, to regulate the admission of the air.

In leading the ventiducts for the foul air, care should be taken to have these properly arranged. In most cases there is a loft above the range of stables, in which hay is kept: it might be awkward to pass the ventiducts through the space; but if the room taken up by them is of no great consideration, we would recommend them to be carried right through the space to the external roof. A ventiduct should be placed in the ceiling in such case, above the stall, as near as may be in the centre, so that the air will at once be led off. The ventiducts should have valves to regulate the admission of the air, and be regularly finished at the top. In cases where the ventiducts cannot be led through the space at once to the external roof, air channels must be made in the wall at the head of each stall, or at the ceiling above the windows opposite the stall. These should have valves at their apertures in the interior; and, at the place where they open into the external atmosphere, they should be provided with tubes carried some eighteen inches above the level of the wall, and finished regularly at top. In all cases where it can be done, we would recommend the ventiducts to be continued from the inner ceilings through the space, and out to the external atmosphere, taking care to continue them at least twelve inches above the level or ridge of the roof. In stables well supplied with means for admitting fresh and withdrawing foul air, the doors and other openings may be as tight as possible—no air entering through them—yet the interior will smell sweat and clean. From the suggestions we have given relative to the ventilation of public buildings, the practical man will have no difficulty in applying the principles to stables, always remembering to have a much larger supply of fresh air secured, than for public buildings, for human beings.

There is a variety of agricultural structures to which the principles of ventilation we have practically illustrated may be beneficially adapted. In order to enable the reader to apply these, we will give one or two examples.

And, first, as to drying-houses for grain, wool, seed, &c. As no drying-house can be thoroughly independent, in its action, of all external circumstances, without the application of heating apparatus, we will suppose, for sake of the arrangement we have adopted, that the reader has, in Chapter V., received a knowledge of the rationale of the process of warming, by the different modes explained.

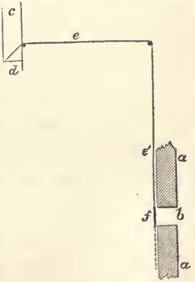
In the construction of drying-houses, two things should be borne in mind: first, the nature of the principles which regulate the process of drying; secondly, the mode of arranging the substances to be acted upon, so as to present them in the most favourable position to the action of the drying agent.

All drying consists in applying such a degree of heat as will convert the moisture contained in the substances to be operated upon into vapour, and in taking advantage of the affinity that air has for moisture. This affinity, acting more or less strongly at all times, is greatly increased by raising the temperature of the air, thereby producing an effect equivalent to a diminution of atmospheric pressure on the exterior surface of the articles operated upon, which very much facilitates the removal of the inherent moisture. It should be remembered, however, "that though the air has affinity for moisture, it can absorb it only in the state of vapour; and therefore, as much heat as will convert all the water in the goods into vapour, will still be required besides that necessary to heat the air, the action of the air's affinity being chiefly effectual in accelerating the process of drying. Currents of air passing through or between the articles to be dried materially assist the drying, inasmuch as each succeeding volume of air passed receives its quota of moisture, which it carries off. As it is evident that dry air will be most effectual, care should be taken not to admit the same quantity of damp as of dry air. In cases where the air is damp, it should be admitted sparingly, and the temperature increased, " otherwise," says Tredgold, " there will be a want of heat. For whatever air you admit carries off heat in proportion to the quantity; and if it be already saturated with moisture, it carries off less water: but you give it the power of absorbing a greater quantity by raising its temperature."

Having thus briefly shown the principles of drying, without at all entering into the somewhat abstruse points of the question, we will proceed to the practical details of the construction of drying-houses, in the explanation of which will be found the modes recommended to attain the second desideratum we have previously mentioned—namely, the proper disposition of the materials to be dried.

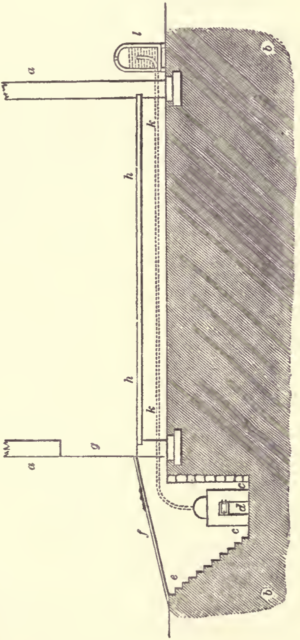
Houses for drying grain, &c., can in some small measure be made effectual without the aid of heating apparatus; but the agriculturist may rest assured that it will be most conducive to his interests in constructing a drying-house to adapt thereto a well-arranged and efficient contrivance for heating. With it he will find that, in course of time, the extra outlay will be amply repaid, and his additional trouble fully compensated by his independence of all external circumstances, such as dampness, closeness, &c. of the atmosphere.

In making provisions for the withdrawal of air from the interior of drying-houses, the size of apertures will be found by the following. By a series of experiments, which it is here unnecessary to give, Tredgold found, that for each 270 feet of surface of pipe, (steam or hot water, see Chapter V.,) 775 cubic feet of air were to be passed through the drying-house. The rule he gives is this: — Divide 7.75 by the square root of the height of the ventilating tube in feet; the area will be the amount of area required for the ventiducts. "The height must be measured from the centre of the hot chamber (containing the pipes) to the aperture where the steam and hot air go out into the atmosphere. Thus, if the height be 25 feet, the square root of 25 is 5, and 7.75, divided by 5, gives 1.55 square for each 270 feet of pipe surface." Thus, it will be seen that for every 270 feet of surface of pipe, one and a half feet of area for air ventiducts should be allowed. The apertures for the admission of fresh air should be of the same size, if admitted by pipes; but it will be better in all cases, in order to prevent too sudden an influx of air, to make them at least one-third larger. The supply of air should be under efficient control; valves should be used to regulate its admission: these should also be supplied to the egress ventiducts at the top. As the amount of air admitted should be proportionate to that sent out by the egress ventiducts, the valves in both them and the ingress should be opened to the same extent. Thus, when the egress ventiducts are opened one-half; the ingress ventiducts should also be opened one-half; whatever may be their respective areas, the proportion should invariably be maintained. The annexed diagram will explain this: *a a* is the wall; *b* the aperture for supplying the interior with air; *c* the ventiduct for leading off the vapour and heated air, supplied with a valve *d*; the cord *e e′*, passing over pulleys, (not shown in the diagram,) leads from the valve *d* to the "damper-valve" *f*, suspended in a frame, close to the inside of the opening. An inspection of the figure will show how, when the valve *d* is opened by pulling down the cord *e′*, the valve *f* passes past the aperture *b* in a corresponding proportion. If the aperture *b* is flush with the ground, a space must be made, into which the



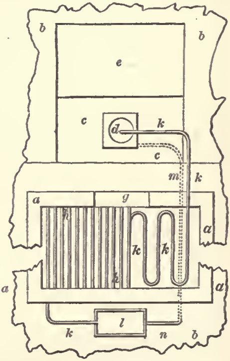
valve *f* can descend. To know the degree of opening of the valves, an index, such as described in Chapter II., may be attached to the wall, near *e'*, and a pointer fastened to the cord, so adjusted that, when the valves are shut, it shall point to the

Fig. 3.



word "shut;" the words, "open," "half," and "three-quarters," being at their respective places on the index.

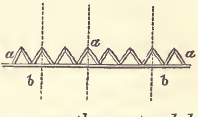
We will now explain Figs. 3 and 4, which contain a section and plan of the general arrangements of a drying-house for grain—premising, first, that the reader has understood the reasons we have given for recommending the system of heating by hot-water pipes (which will be found in Chap. V.) Fig. 3 is a longitudinal vertical section of a drying house; *a a* the walls, *b b* the ground on which the house is built, *c c* a place excavated in front of the house, *e* the steps by which access is gained to the floor of *c c*, *d* the furnace and boiler of the heating apparatus, *f* the gangway stretching across the excavation to the door *g*; *h h* a false flooring, composed of small beams, two inches thick and four deep; having an interval or space of two inches between each, through which the heat from the pipes *k k* ascends; these pipes traverse the space between the floor of the building and the false flooring *h h*; *l* is the feed cistern (alluded



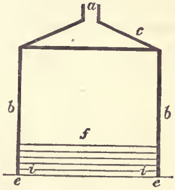
to in Chap. V.) Fig. 4 is a plan of the building, the same letters referring to it: *k k* is the ascending pipe, curved as seen, and should be supported and kept clear of the ground by non-conducting supports—say bricks or blocks of wood; the line of pipes should be flush with, or a little above the level of the bottom lines of the fresh-air ventiducts; the curves in the pipes should not be less than two inches radius—that is, part of a circle four inches diameter—sharp curves or turnings reducing the flow of the water. This ascending pipe should be continued to within sixteen or eighteen inches of the surface of the water in the feed-cistern *l*, shown in Fig. 3; *m n*, the return pipe, should be covered with non-conducting material. The arrangements of every drying-house will, of course, vary according to local circumstances; but the two figures given will be sufficient to enable any one to put the plans into practice in almost any situation.

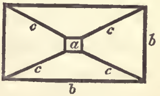
As the rules for finding the apertures of the ventiducts depend upon the knowledge of the quantity of pipe in the interior, we will now explain the rules for finding the required surface for heating the air supplied to the interior. The temperature of the external air that supplies the ventilation differs from that of the heated, supplied to the interior. The difference between them must be ascertained. Mr Tredgold is of opinion that the difference will never be more than 50°. The mean temperature of the pipe must also be taken into account; as likewise that at which the air in the interior is proposed to be maintained. Supposing the former to be 140°, and the latter 100°, the rule will stand as follows:—" Multiply the number of cubic feet per minute, of air to be heated, to supply the ventilation and loss of heat, by the difference between the temperature the house is to be kept at, and of the external air in degrees of Fahrenheit (in the case we have supposed 50°,) and divide the product by 2·1 times the difference between the mean temperature of the pipes (140°,) and the temperature of the house (100°,) this quotient will give the surface of pipe required." In a pipe one inch in diameter, it takes 3·28 feet to give one foot of surface. As there is a considerable loss of heat through windows and doors—in the former it is " simply proportional to the surface of glass exposed to the external air"—we would recommend as few windows as possible to be made in drying-houses, and the doors to be made double. Mr Tredgold gives the following rule, by which the amount of cubic feet of air to be warmed per minute is found:—" To the length in feet, multiplied by half the greatest vertical height in feet, add one and a half times the whole area of glass, and also eleven times the number of doors; the sum will be the number of cubic feet to be heated in a minute from the temperature of the external air." This quantity found is to be used in the rule above for finding the surface of pipe. In all provisions for heating, it is better to err in excess than deficit. The current of air through the interior should not be too great, as the obvious effect of great velocity will be the drying of the exterior of the goods, while the dampness will still remain in the interior. To insure the current in every part of the house, the area of the ventilators in the top should be distributed pretty equally over the roof. Thus, if the area required is six feet, there should be six ventilators of one square foot each. The disposition of the grain to be dried is matter of no small importance; the sheaves as taken from the field are too thick, and should be separated. In Fig. 3, the small squares *i i* represent sections of wooden beams, stretched across the breadth of the house, and resting at the ends on projecting brackets, fastened on the walls. If these are placed two feet or so apart, room will be given for spreading out the grain, putting up a few beams, laying in the grain, and thus proceeding till he gets to the last near to the door. When filled, the door should be carefully closed, and the heat of the pipes kept up to the desired maximum; this can be ascertained by a thermometer placed on one of the pipes, below the false flooring. After the grain is extracted from the straw and is required to be dried, flat shallow cast-iron or tin dishes, punched with holes, should be laid on the false flooring, and the grain laid in these; the heated air will pass through the apertures in the dishes. We trust that the hope expressed by Mr Tredgold will be realised, that "in many districts the use of artificial heat will increase, and the loss of much valuable grain be prevented. Besides," continues the same author, "with the knowledge that he can save his corn in good condition in a full season, the farmer will have a mind more at ease: he becomes secure of that which, in the ordinary course, is very frequently injured, and sometimes altogether lost. He may also turn the same contrivances to advantage in a wet hay harvest, and temporary erections will soon be changed for more permanent ones. The certainty of artificial heat will be to the farmer as important as the certainty of power is to the sailor; and these two classes of men, who have hitherto depended more than any other on seasons, will both receive great benefit by the application of heat. It is not farmers alone that will be benefited by drying corn artificially in backward and wet seasons; for, in such cases, the whole population will feel the benefit of this plan. Unsound grain makes very indifferent bread, doctor it as you like; and the evil is too frequently a general one."

In arranging wool in a drying-house, instead of laying the fleeces on the beams in the manner previously described for grain, they may be suspended from the beams by small pieces of cord; the great desideratum being to expose as much of the surface to the action of the current of heated air as possible. For drying the various kinds of seed, the plan recommended—namely, to use flat shallow dishes with perforated holes—will be the best. The bodies should be shifted now and then, by means of the hand or a wooden shovel. In arranging peats, turf, &c. for drying, they should be placed two by two on the beams leaning against one another. *a a* are the peats; *b b* the beams on which they rest; the dotted lines show the course of the upward current.



Temporary structures for drying may be easily raised. The simplest mode of doing so will be as follows: Mark out the size of the house, and make an excavation twelve inches deep, making the floor hard and dense as possible, by ramming. At each corner, drive in tightly square beams, of height sufficient for the elevation of the house; connect these firmly together by simple tie-beams. The annexed figures will amply illustrate the mode of construction—*b b* the beams

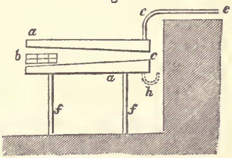




at the corners. The mode of forming the roof is thus: Make a square box *a* for the air to escape through; pass from the corners of this, when fastened in the centre of the roof, beams *c c c c* to the corners of body of the structure, thus supporting the box *a* above the level of the head of the beams *b' b*, as seen in the upper figure. The spaces between the supports *c c* are covered in by a tarpaulin, all except the opening of the ventiduct *a*. This tarpaulin should be continued down the sides and ends of the building at least one foot, so as to insure as much tightness as possible. The sides may be closed in by clap-boards, overlapping one another; or more cheaply, and as efficiently for a temporary structure, by tarpaulin nailed tightly to the beams *b b*. But whether boards or tarpaulin be used, care should be taken to carry out the following recommendation.—To supply fresh air, a space, as *i i* in the upper figure, is to be left all round on each side and end; *e e* is the line of the ground; *f* the clap-boards—this space can be left by beginning the boarding twelve inches or so from the ground, or continuing the tarpaulin down to within that distance of the ground. The upper figure is a side elevation, and the lower a plan of the roof of the structure. A more simple plan for the roof might be made, by adopting a large sheet, stretched flat across the roof, with a hole or holes in the centre for the egress of air.

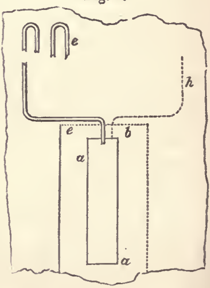
In windy weather such a house will be very efficient in drying wet hay, &c.; but simple heating apparatus may be adopted with considerable facility, which will render its use available in all weathers. For the sake of arrangement, we will here give a description of a very cheap and portable heating apparatus, the action of which depends upon the circulation of hot water in tubes, explained in Chapter V. Fig. 1 is a section of the apparatus.

Fig. 1.



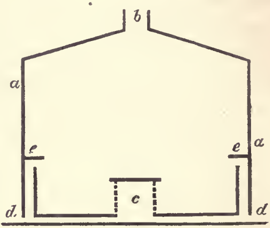
Procure a large iron tube *a a*, open at both ends; to this fit another tube in the inside, the mouth *b* of which is larger in diameter than the other end; let the difference between the diameter at the largest end and that of the external tube be two inches, thus leaving a space of one inch all round; the small end should be one third of the diameter of the large. The ends of the tubes should be joined together by plates of iron, well soldered with brass, so as to make a perfectly tight communication running right through the external tube *a a*. The tube thus fitted should rest upon small horses or trusses *f f*; in the large end *b* a small grating should be inserted, in which charcoal, peat, or common coal may be burned; and at the small end, a tube or chimney may be attached leading upwards for a few feet. This will increase the draught, to regulate which a valve may be inserted. Now, supposing the space between the two tubes to be filled with water, and the fire at *b* kindled, it will be easily seen how the heated air, impinging upon the interior surface of the pipe in its progress through it, will soon heat the water contained between the space of the two tubes. Here, then, is a supply by which a congerie of pipes in the interior of the drying-house may be supplied. As the ascending currents of heated water should be taken advantage of, in promoting the circulation through the pipes, the main tube *a a*, or "furnace boiler," should be situated at a lower level than the floor of the drying-house. This may be simply effected by making an excavation, as shown in the figure, at an end of the house. To the upper side of the "boiler" near the house, attach a pipe, say one inch diameter at *e*, communicating with the space between the two tubes; lead this pipe up to the drying-house, as shown in Fig. 1, and cause it to describe a series of curves, as seen in Fig. 2; and finally lead it to the middle of a tank of water which will be the feed-cistern;

Fig. 2.



bring from the bottom of this cistern a pipe *h*, as seen in the dotted line on Fig. 2, and attach it to the under side of the furnace boiler, as shown at *c* in Fig. 1. There will thus be a continual current of hot water proceeding from the boiler through all the convolutions of the pipe *e e* to the feed-cistern, and through the descending pipe *h* to the furnace boiler, again to be heated—the amount of evaporation escaping through a small pipe in the cover of the feed-cistern. The internal tube of the boiler should be made of thin copper, which will last longest, and communicate the heat of the fire quicker than if made of iron. The tube of the boiler should be wrapped round with felt, or other non-conducting material, as also the parts leading from the house. This will prevent the loss of heat. The whole apparatus can be made portable very simply—by attaching screw couplings to the pipe where it enters the upper and lower sides of the tube, as at *e* and *h*, and at the places where they enter the feed-cistern. By unloosing these, the tube will be separated from the boiler and feed-cistern, and conveyed where necessary—the congerie of pipes in the interior being lifted in one piece; or even this may be detached one piece from another, by screw couplings. The congerie of pipes should, when in use, be kept up from the floor, in the manner described for grain drying-houses. The hay, &c., to be dried in the temporary house we have described, may be placed on hurdles easily constructed of pieces of scantling.

The principles of ventilation should be applied to other agricultural structures not yet noticed. Thus swine-cots, hen-houses, &c. can be efficiently constructed, so as to combine with neatness and cheapness the amount of comfort necessary for the animal. Dairies cannot be too well supplied with pure fresh air; to attain which, the sites fixed upon should not be in the neighbourhood of aught that contaminates the supply. The annexed figure will enable the agriculturist to apply the principles we have elucidated: *a c* the walls; *b* the ventiduct, for allowing the air to pass out; *c* a table, nearly the length of the apartment—the inside of which is supplied with fresh air through the ventiducts *d d*, and the sides and ends of which are perforated. The shelves *e e* are supplied with air through the ventiducts; as seen, these stretch across the whole length of the room, so that the air may have access to the whole range. The shelves may be made of light frame-work with diamond-shaped apertures. Cast-iron frames would in every case be preferable,



—light, cool, and easily cleaned. Instead of using the top of the table *c* to place dishes upon, the inside may be fitted up with perforated shelves, the top lifting up as a lid; or side-doors may be made: these should fit very close and tight.

We trust that, in our remarks, we have very plainly elucidated and explained the principles upon the application of which the heating and ventilating of agricultural structures depend, and that the practical farmer will have no difficulty in applying these, in any case where they may be considered necessary.

CHAPTER V.

WARMING OF BUILDINGS—CONSTRUCTION OF FIREPLACES—SMOKY CHIMNEYS.

"Dry be your house—but airy, more than warm."—ARMSTRONG.

THOUGH much consideration has been given to the nature of heat, still nothing has yet been received as a true explanation of the phenomena which it presents; and among scientific men its real nature is still a subject of dispute. As it is foreign to the subject of this treatise to enter into a long discussion of the different theories promulgated, we will content ourselves with explaining its effects, and the simplest mode of applying them to the warming of public and private apartments.

The two methods by which warm bodies afford heat are "radiation" and "conduction," or by "contact." "Radiation signifies the rapid emission of heat and its passage from one body to another, in the same manner as rays of heat pass from the sun to the earth." It is radiant heat we receive from a fire. "Conduction signifies the slow and direct communication of heat from any warm object, to another in actual contact with it." A stove affords heat principally by conduction, as do also pipes containing steam or hot water. To assist the reader in forming an idea of the effects of heat, as above explained, we here give some of the "Memoranda" compiled by Dr Reid. "Different bodies vary much in their power of radiation: those with rough and porous surfaces radiate well. Bodies that radiate well when hot, absorb it quickly when cold; as good radiators are also good absorbers of heat. Polished metals are bad radiators of heat, bad absorbers of radiant heat, but powerful reflectors, throwing back a large portion of any radiant heat that falls upon them. Metals are good conductors of heat, taking it rapidly from any object warmer than those with which they may be in contact, and evolving it equally to those that are colder, and in contact with them. Glass, brick, porous solids—as charcoal, fur, cotton, and wool—are bad conductors of heat. Bad conductors are used for surrounding materials to be kept warm or cold, that heat may not escape from them or enter to them. The most powerful combination, for giving or acquiring heat, is formed where the material is composed of metal, that the conductors may be good; and the surface non-metallic, but porous, soft, or painted, that the absorption or radiation may be powerful. Again, in the most perfect arrangement for retaining heat, the substance should be made of a non-conducting material, and the surface of a brilliantly polished film of metal, that it may neither conduct nor radiate well, but be powerful in reflecting."

In cases where the heat is communicated between substances at a greater or less distance from each other, radiation is the term applied. When the "heat is diffused by means of the air—which, being warmed by contact, is expanded and put in motion, and communicates the heat it receives to the solid bodies in the room—then the term conduction is applied."

There is a considerable difference, in the generality of cases, between the heat communicated by radiation and that by conduction. By the latter, air may be too much heated, so as to *burn*, as the expression goes, its vital humidity, by which it is made dry and unpleasant: moreover, if too highly heated, it increases the effect of the warm air to absorb moisture. Hence, a party with wet clothes, in entering an apartment filled with overheated air, is in great danger of catching cold; as the evaporation of moisture from his damp clothes, carried on by the warm air absorbing it, the abstraction of heat from his body will be considerable. That cold is produced by evaporation is amply proved by the beautiful and decided experiment of Professor

Leslie, who actually froze water by absorbing the vapour by means of sulphuric acid as it rose from the water. The experiment may be familiarly tried, by waving the arm swiftly in the air, taking care that its surface is wet; or, still more convincingly, by pouring ether on the back of the hand. In the latter case, the evaporation being extremely rapid, the degree of cold produced is absolutely painful. An apartment warmed by radiant heat is, to a very considerable extent, free from these disadvantages; as the air is cooler than the objects receiving heat from the fire. "The rays of a fire produce no more vapour from moist bodies than they supply with heat; and therefore they produce no cold when unaided by the affinity of warm and dry air. Moisten the bulb of a thermometer, and expose it to the action of warm dry air, and it will sink down several degrees; but when moistened and exposed to the rays of a fire, it rises. A person warmed by radiant heat is always unequally warmed; and if the introduction of cold air be injudiciously managed, he may literally burn on one side and starve at the other."

It is evident that large spaces cannot be warmed by radiant heat equably and effectually; for, in the use of a large surface of open fire, the heat near it would be insupportable; while, far away, the influence would scarcely be perceptible. To increase the number of fireplaces would be as difficult, and far more dangerous—inasmuch as the liability to fire would be increased, besides the expense of maintaining such an expenditure of fuel, and the creation of dust, ashes, &c. For the purpose, then, of heating large spaces, the principle of warming the air, supplied by conduction, has been adopted; and it will be our next task to show the different modes promulgated and carried into effect, as well as to explain their mode of action.

The plans hitherto in use for heating large spaces are as follows:—Hot stoves or furnaces, steam and hot water. In the first, plates of metal or masses of brick or stone, or flues, are heated in, or by a furnace; and the air to be heated is caused to impinge upon, or pass through these, thus imparting to it a degree of heat which, it is evident, cannot be controlled or regulated as required. The oldest method of heating by such means is what is termed, "the cockle"—the most scientific modification of which was made by Mr Strutt, of Derby, so early as 1772. Its principle depended upon keeping the air to be heated, in its passage over and through brick flues, at such a distance from the heating power that the temperature of the air could not exceed a certain degree. To obtain this desideratum in such contrivances is very difficult; and the structure required cumbrous, and clumsy in size and shape, and expensive to be kept in full operation. Air, when heated to a degree above 212°, or the boiling point, is burnt or desiccated—that is, deprived of its inherent moisture—consequently, causing it to have an unhealthy action on the bodies of those subjected to its influence. Heated air, then, should never be above this point; to attain this desideratum is, with stoves, almost an impossibility. Excluding, then, from our notice, the infinity of stoves vaunted as "perfect and complete in every department," we will only notice those which may be adopted without fear of producing deleterious effects.

The most important of these, and the one most widely known, is the Arnott Stove, so called from the learned inventor. The most striking peculiarity of this stove is, that it "combines extreme economy of fuel with great facility of attendance;" such arising from two causes—the large amount of heat which is detained by the stove, and the comparatively small quantity of air which is removed by combustion." This contrivance being made by so many manufacturers, it is so generally known that it is needless to take up space by giving a detailed description. The principle, however, may be noticed. A large outer case is provided, in the interior of which there is a small fire, the products of combustion of which proceed to the chimney by a series of turns, the air in the interior surrounding these being heated by contact with them. It is to be regretted that many so-called Arnott stoves are by no means made on the correct principles made public in a very generous manner by the inventor.

The Porcelain Stove, recommended by Dr Reid, is another low temperature stove. They are much used in Sweden, France, Russia, and other countries. The plan may be described as an oblong chamber, some ten or twelve feet high, at the lower end of which the fuel is placed. The flue at the top is made of a square tube, leading upwards a short distance, turning to the right, along in a horizontal direction far enough to clear the side of the main chamber; then bent downwards, and, proceeding to the bottom, turning again, running parallel to the floor to the corner of the chamber; bending upwards, and continuing so till reaching a height above the top of the main chamber, equal to the pipe as it first begins; then, stretching across the breadth of the head of the main chamber, and down to the opposite side along the floor, and up, where it is continued to its place of exit. The inside chamber and tubes are all covered by an external case, having apertures at its upper part to admit the heated air to the apartment in which it is placed. They are quite different in their action from the hot German stove, as understood in this country; and Dr Reid says, that, from his own personal experience in examining them, he is enabled to say that he knows no *stove* that produces a more mild, genial, and equal temperature. As the tendency of hot air from all stoves is upwards, to insure their full effect, they should be placed at a lower level than the apartment they are intended to heat.

In heating large apartments, we would by no means recommend the adoption of stoves; we think we have said enough to prove that, expensive in construction and *operation*, they are not by any means controllable in their action. We will proceed, then, to explain the two other modes, which in the generality of cases are now adopted—these are steam and hot water. These, as used for the purposes of heating, are caused to circulate through a congerie of pipes, which heat the air surrounding them, by a combination of the two effects of heat, radiation and conduction—principally, however, by the latter.

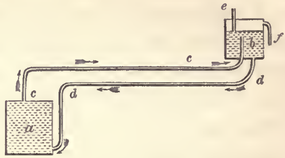
In the year 1745, Colonel William Cook first suggested the idea of employing the heat of steam as a means for warming air. The first patent for this plan was granted in 1791 to John Hoyle of Halifax. His plan was, conveying to the places to be warmed steam pipes, passing these into, round, or through them—"the pipes being first raised to their highest elevation, and then descending with a gentle declivity to a cistern for the condensed steam." In the application of steam to heating purposes, the peculiarities are—the distance to which it may be led from the place where it is generated, the uniformity of temperature at which it can be sustained, and the facility with which it can be led in any direction—upwards, downwards, or laterally. Moreover, the fire-place of the boiler may be made in any place convenient, however far separated from the building to be heated. Thus, cases have been known when the distance from the boiler to the extreme end of pipe has been 800 feet. The steam to supply the pipes is generated in a boiler, and sent through the range of pipes, arranged in number and situation as required—the water of condensation either returning to the boiler or led to a convenient place.

The hot-water system is divided into two classes, —"low" and "high" temperature—the former consisting of a congerie of pipes communicating with a boiler or receptacle placed at a lower level, to which the heat is applied. A receptable at the highest parts or extremity of the pipes is placed, into which the water caused by the expansion flows, and from which it returns again by pipes to the boiler, to be heated anew. Thus a constant circulation is kept up, and, the receptacle or cistern being open to the atmosphere, a higher temperature than 212° cannot possibly be obtained. In the "high" temperature, the pipes are hermetically sealed after the water is put in, allowing ample space for expansion; and by continuing the heat of the fire, a degree of heat may be obtained far above

212°. It will be perceived, however, that if air comes in contact with the metal pipes, it will be as much desiccated or burnt as by the common highly-heated stoves so justly complained of—"to avoid the deleterious effects of which," says Mr Bramah, "has been the principal aim in the application of the process now under consideration."

The mode of heating by hot water was invented and applied in the last century in France. The Marquis de Chabannes strongly advocated it some thirty years ago; he says,—"There cannot be a more perfect idea of the whole operation of the new patent water calorifère, than by comparing its boiler to the human heart, and the tubes through which the water passes to the blood-vessels in the human body. In the water calorifères, the water is in constant movement as the blood in the veins; it goes out of it by an upper tube, as the blood by a valve in the heart. It circulates through the house, ascends or descends at will, and returns into the boiler at the bottom, to charge itself again with fresh caloric, as the blood ascends, descends, and passes again into the lungs to regain a new portion of oxygen, and recommence constantly the same function of carrying heat to the extremity of the body."

The annexed figure illustrates the rationale of this process, where *a* represents the boiler, *b* the feed-cistern, *c c* the ascending or hot pipe, *d d* the descending or supply pipe. The water from the feed-cistern descends the pipe *d d*, and fills the interior of the boiler *a*; by the action of the fire the temperature



of the water is raised, and, according to the laws which regulate the motions of hot fluids, it flows up the pipe *c c* to the cistern *b*. A regular and unintermitting descent of cold water down the pipe *d*, and hot water up the pipe *c c*, as indicated by the arrows, goes on until the temperature of the whole body of water is the same. Properly speaking, this never happens, as a portion of heat is abstracted from the pipe *c c* by radiation and contact: the motion may be said to be continual, so long as the fire is properly supported. The feed-cistern is supplied with cold water by a pipe *e*, and a waste-pipe *f* is provided to allow the escape of the water of expansion. This, being open to the atmosphere, also allows of the escape of any vapour, so that the heat never can exceed that of 212°. If the feed-cistern is at a considerable elevation above the boiler, as the pressure of the water therein is greater than ordinary, the boiling will vary in proportion to the height. Thus, in an apparatus in which the boiler is 60 feet below the cistern, the boiling point is 270°, instead of 212°. To prevent all loss of heat from parts not required to give out heat, the boiler, cistern, and part of the pipes necessary, should be covered with non-conducting materials. The mode of applying these we will describe hereafter. The cause of the circulation of the hot water in pipes is produced by the "unequal density of the fluid, arising from the difference of temperature in the ascending and descending columns of water connected with the heating reservoir; and its velocity is governed by the height of the columns." In the "high temperature" system there is no communication whatever with the external atmosphere, the tubes being hermetically sealed after being filled with water. The feed-cistern is thus dispensed with, and an expansion tube substituted in its place, at the highest part of the range of pipes: the size of this expansion tube is one-fifth of the contents of the whole piping.

As to the comparative merits of the two systems —heating by steam, and by hot water—we do not consider it necessary to enter into a long discussion. But in the generality of cases, where large spaces are to be heated, we would recommend the adoption of the latter mode. "As contrasted with steam heat," says Mr Bramah, "it may be remarked that the extreme simplicity of the hot-water apparatus, and its freedom from those casualties which are incident to an accumulated temperature in steam, renders it a desirable means for adoption in domestic economy; for while, on the one hand, heating by steam necessarily involves liability to accident, from the increased ratio of the force of vapour, as compared with that of its sensible heat, and which is frequently occasioned by the derangement either of the feeding or the safety apparatus; on the other hand, by the substitution of hot water, this serious inconvenience is avoided: while the expenditure of the water is, in this latter mode, no greater than the quantity lost from leakage; or the slight evaporation which can occur is limited to the effect of overfiring, by which water may be driven out of the upper part of the pipes, or from the feed-cistern of the apparatus, into the channel provided for its escape, so as to produce for a short interval a reduction in the temperature of the remaining quantity, by the immediate influx of cold water from the source to supply the deficiency thus occasioned." And the Marquis Chabannes says—"Hot water is preferable to steam in many respects. Steam requires a strong fire, and to be always kept up; whereas very little fire is sufficient to keep up the heat in the water when once boiling, and to renew the caloric, which is continually passing through the different apparatus for spreading the heat: it is therefore much more economical." For agricultural structures, steam certainly possesses the advantage of a ready means for preparing mashes and boiling water in a very short time. But to set against this, the steam often not being readily raised when required, and from the time taken up in doing so, to keep steam apparatus in continual action involves a very considerable degree of attention and outlay of fuel; while in that of the hot water, a very small fire will keep up a considerable degree of heat for any length of time. For public buildings, hot water should in all cases be employed; but in some districts, where fuel is plentiful, and parties may be inclined to fit up steam apparatus, we consider it best to explain some of the minutiæ of construction of such, as well as of hot-water apparatus.

Steam Apparatus—Construction—Boilers.—We do not consider it at all necessary here to enter into the minor details of construction, such being known to the mechanics who will be employed in the manufacture of the apparatus, but merely to give general hints, to enable the parties fitting up such to see that the conditions required to make it efficient are fully carried out. The shape of the boiler we would recommend is that known as "cylindrical." It is easier made than the spherical, and possesses many of its advantages. It may be made of copper, but thin iron will answer well enough. Care should be taken to have the metal, on which the flame of the fire infringes, thin; by being so, considerable time will be saved in raising the water to the boiling point; and it will be, moreover, more desirable, as the outer surface will not be burnt, by the intenser heat which thicker metal would require. Again, it is found that even the best conductors retard the progress of heat, if of considerable thickness. In applying the heat of the fire to the surface of a boiler, care should be taken not to increase its extension when the heat is less than 212°, as it is evident that there must be a disadvantage to allow heated air or smoke to come in contact with the boiler, after its temperature is reduced below that of boiling water: the smoke should quit the boiler at the temperature of the steam. The space allowed for water should be a little less, but certainly not greater, than half of its cubical contents; and the space allowed for steam should not be made greater than the cubical contents of the whole range of pipes to be supplied. Hassenfratz recommends the depth of water to be one-sixteenth of the area: this proportion is only applied to evaporating boilers. Tredgold says, that, "for producing steam, the most effect is obtained when the horizontal area of the boiler is about 21 superficial feet. The apparatus for a boiler consists of a feed-apparatus, to insure a regular supply of water; a safety-valve, to allow the steam to escape when of too high pressure; gauge-cocks, to ascertain the height of water in the boiler; and a man-hole door, to permit of entrance to clean the interior." The feed apparatus is simply described: To the upper end of a long tube, entering through the top, and proceeding within a few inches (say 3 or 4) of the bottom, let a small cistern be attached: this may be most conveniently made wide at the top, and sloping down on all sides, till it attains the diameter of the pipe on which it is fastened. At the head of the pipe fix a conical valve, opening upwards; the stalk of this should project 3 inches above, and at least 6 below, the body, which rests on the conical seat. To the side of the cistern, on a line with the length of the boiler, attach a standard, in which should oscillate a lever, the length of the short arm being half that of the long. To the short arm pass a rod or wire, working in a centre, to the upper stalk of the conical valve, to which it should be attached by a movable joint. To the long end of the arm pass a wire, down to and through a steam-tight opening in the boiler; fasten a stone float at the end of this, at such a height that the bottom line should correspond with the proper line of the level of the water, when the boiler is filled to its proper height. It is easily seen how that, when the water is evaporated, its level will sink, the float will descend with it, pull down its wire, and by that means depress the long end of the lever—thus raising the short, and, through the connecting wires, the conical valve out of its seat, allowing the water to pass down the pipe. The cistern should be supplied with water through a pipe, the quantity of water flowing through which should be regulated with a ball-cock. A waste-pipe should also be provided, to take off any surplus water. In constructing this feed-apparatus, it is of the highest importance to make the tube, or rather the elevation of the cistern, sufficiently high, to counterbalance the pressure of the steam in the boiler. On a rough calculation, a pressure of steam, 15 lb. to the square inch, will sustain a column of water 30 feet high—so, for every lb. of pressure of steam, two feet of height should be allowed. It is better, however, to err in excess than deficit; so $2\frac{1}{2}$ feet may be allowed. For supplying steam for heating purposes, no greater pressure should be given than 4 lb. to the square inch. A safety-valve will be easily constructed, by inserting a conical brass-valve in the upper side of the boiler. The stem of this should project 6 inches into the interior, and 3 above the exterior of the boiler. Weights, having holes in the centre of each, can be slipped over the upper part of the stem to regulate the pressure. It will be perceived that the feed-apparatus, formerly described, if its height is regulated exactly to the pressure required, will act as a safety-valve; the steam forcing the water up the tube, consequently, in a corresponding ratio, providing more space for its increased bulk when the pressure is removed. The gauge-cocks should be two in number. Provide two common stop-cranes, with pipes attached: the length of one should be sufficient to reach the water-line, and at least one inch below it; the other should reach a little *above* the level. When these pipes are passed through holes made in the upper side of the boiler, and properly fastened, the stop-cranes will be outside, a few inches above the boiler. If water comes through one, and steam through the other, all is rightly adjusted; but if steam comes through both, there is too little water in the boiler, and the feed-pipe should be looked to. If water comes through both, there is too much of it. The man-hole door should be of sufficient size to allow a person to have free access —it should be tightly fastened down with a well-secured joint.

Furnaces.—The peculiar construction of such will depend upon the shape of the boiler. The air should have free access to every part of the fuel which is on the grating — the air supplied passing generally through slits or apertures, made between the bars on which the fuel is laid. The area of these should be much larger than that of the place at the front of the furnace, which supplies air to the ash-pit. The bars of furnaces are generally one inch wide at the top, each interstice being $\frac{1}{4}$ or $\frac{1}{2}$ an inch: it is found that one square foot of aperture of these admits sufficient air to consume coal, which will evaporate one cubic foot of water per hour. With a very quick draught, a much less surface will suffice. The extent of surface of boiler exposed to the flame of the fire is found, in the general run of iron boilers, to be fifteen square feet, for each cubic foot of water evaporated per hour: of this surface one-third is reckoned horizontal and two-thirds vertical. The area of the chimney, to carry off the gaseous products with sufficient velocity, is of importance to be known. "From an examination of the best boilers," says Mr Scott Russell, "it appears to us decided, that one-fifth of the area of the fire-grate, gradually diminishing to a chimney, which shall have one tenth of the area of the fire-grate, is an excellent proportion:" the standard will therefore be one-fifth, diminished at the chimney to one-tenth part of the area of the grate. "The chimney should be of the same diameter throughout its interior; and if of 40 feet height, and one-tenth part of the area of the grate, it will give an abundant draught. If the height of the chimney be greater, then this area may be diminished as the square root of the height is increased."

The space for the fire should be lined with good fire-brick, built with fire-clay, and the rest of the furnace with good well-burnt bricks. With the exception of the door, bars, and dumb-plate at the mouth of the furnace, iron should not be used in its construction. As it is of importance to confine the useful heat as much as possible, the boiler surface exposed to the air should have an outer case; in the space between this and the boiler, non-conducting material should be placed—or this effect may be more easily obtained by building and plastering an outer case of brickwork round the boiler. A damper should be provided at the throat of the chimney; an excellent door, which may be opened to any extent, may be obtained by adopting the plan of a "damper valve," as given in Chapter II. Mr Tredgold recommends the fire bars to be placed sloping downwards, towards the back, and the coals to be placed only at the front when supplying the furnace. The fuel thus placed will be gradually heated, ready to enter into combustion when pushed forward by the stoker; and a new supply of fuel should then be added, in the place of that which has been thrust forward into the fire. The gases which distil from the fuel, having to pass over the red-hot embers, which are supplied with air from the ash-pit, (through the bars,) will generally be wholly consumed in passing the throat of the chimney.

Pipes.—The best material for the pipes is cast-iron; it gives off, when heated, no deleterious or unpleasant exhalation, and is cheap, and easily fitted up. They should be black, and rough on their surfaces, in the spaces where they are to give off the heat. The diameter of pipes should never exceed six inches, nor be less than three, where the number is considerable. "The space for steam, it should be recollected, is quadrupled by doubling the diameter of the pipe, while the quantity of surface, on which the effect of the pipes depends, is merely doubled." In cases where a large surface is required, it may be better to have two pipes. Where heat is to be given out slowly, the pipes may be made large, and filled with pebbles, broken flint, properly cleaned. "By adopting this method, the pipes would not afford heat, till the flints had absorbed their specific quantity, and this quantity would remain to be slowly given out, after the steam had ceased to flow from the boiler." It is of importance to have the pipes not too thick; they should be thick enough only to secure perfect castings. In fitting up pipes, due allowance should be made for the expansion; if this is not attended to, the joints will inevitably leak, every time the apparatus is used. The expansion is found to be a little more than the $\frac{1}{8}$th of an inch, for every 10 feet of cast-iron pipe, where the temperature is increased from the freezing point to 212°. As lead pipes may be advantageously used, for leading the water of condensation to the boiler, one-fifth of an inch for every 10 feet will be sufficient. The iron steam-pipes, in order that they may expand freely, should be supported by small rollers, moving on low brackets. The best method of joining the pipes is by having flat flanges at the ends of each length, with bolt-holes bored in them—the holes of the one corresponding with those of the other. As an efficient and elegant substitute for this white lead and rope yarn joint, used frequently, we would recommend the flat thick rings of vulcanised India rubber: they form excellent joints, when screwed tightly between the flanges. All the pipes should have an inclination downwards to the boiler, so that the condensed water may run freely thereto. If it is wanted to make as much of the heat as possible, the condensed water may be allowed to remain till cool, and drawn off by stop-cocks, placed at intervals. These should be opened before the steam is admitted, and closed after the pipes are filled; the air will thus be driven out. It is best in all cases to return the water at once to the boiler—that is, if the boiler is placed at a lower level than the pipes. As the returning water, running down the pipes, may condense the steam in its passage through them, it is better to have a small lead or iron pipe provided, to lead the water of condensation to the boiler.

As it is important to confine the heat to the pipes, in places where they are required to retain it, they should be covered with felt or cotton, well wrapped round with cord and painted white. When the steam is conveyed to a distance, under ground, a dry drain should be made, filled at the bottom with loose materials, as broken stones; and surrounded with dry ashes, and covered with tiles, cemented closely together to keep off the water. Boxes made of wood, and covered with the same composition, recommended for the fresh air ventiducts, in Chapter II., and filled with dry ashes or animal charcoal, would answer still better.

Proportions of Pipes.—For churches and public buildings, the rule is very simple. Three things should be borne in mind, in calculating the necessary amount of air to be heated—the loss of heat from the glass, from the ventilation, and through the chinks of the windows, doors, &c. The area of the glass exposed to the external air must be calculated; and, when found, the following is Mr Tredgold's rule: "The quantity of cubic feet to be warmed in one minute should be equivalent to four times the number of people the room is intended to contain, added to eleven times the number of external windows and doors, added to one and a half times the area or feet of the glass exposed to the external air: the sum will be the quantity in cubic feet." This quantity, thus found, is to be used in the following rule, by which the surface of pipes is found: "Multiply the cubic feet per minute of air to be heated, by the difference between the temperature the room is to be kept at and that of the external air, in degrees of Fahrenheit's thermometer, and divide the product by 2.1

times the difference between 200 and the temperature of the room: this quotient will give the quantity of surface of cast-iron steam pipe that will be sufficient to maintain the room at the required temperature." To make this calculation, the temperature of the external air, that supplies the ventilation, is to be known at the extreme case of cold, which for the day may be taken at 30°; but, for night, may generally be assumed at once to be at zero, as the cold is seldom more intense in this country. The temperature at which it is proposed to maintain the room, or place to be heated, at the same season of cold, is also to be settled. The mean temperature of the surface of the pipe containing the steam, at the ordinary pressure is 200°. In calculating the size of pipes for churches, if the windows are double, the loss of heat from ventilation is alone to be accounted for; "if simply air-tight, the number of them multiplied by 11 may be omitted." To ascertain the number of cubic feet cooled from the temperature of the room to that of the external air, multiply the area of the surface by 1.5, and the product will be the number of feet. Mr Tredgold gives the following, which we give as an example of the mode of proceeding in the calculations: "Let us suppose a church for 1200 people to contain 100,000 feet of space, and that the congregation is, in winter, on an average 600; and that there are 28 windows, with 1000 feet of surface of glass, and that it is to be kept at 60°, when the external air is 30°, or 30° above the external air. The loss of heat from the glass will be 1500 cubic feet. From ventilation of 600 people, 2400 cubic feet, and from the escape through windows, 300—in all, 4200 cubic feet to be warmed per minute: the surface of steam pipe required for this, will be 428 feet. For this he recommends pipes four inches diameter. To find the time required to heat the *whole* content of the church, the ventilation being stopped, divide the space in the room by the quantity of air to be heated in one minute—the quotient will be the number of minutes required. Thus, in the example we have given, 100,000 divided by 4200, equal to 24 minutes—the time the boiler would require to be in full action.

The rules thus given may be easily applied to workshops, halls of large mansions, &c.

Distribution of Pipes. — This is a matter of very considerable importance, and may be carried into effect in two ways: first, by erecting a congerie of pipes in an apartment distinct from the building, at a lower level, through which fresh air is impelled, and driven into the church by means of machinery, or drawn in by the force of the upward current of ventilation; secondly, by distributing the pipes in the interior, according to local circumstances: the latter mode we are inclined to recommend. Of course, in both cases, the boiler and fireplace are in an apartment at a lower level. In cases where the gratings are made in the passages, the pipes should be led to these; indeed, a narrow grating, the whole length of the passage, under which the pipe would lie, would be advantageous. In other cases, the pipe has been led along the walls, at the head of each pew, thus affording a good supply of heat. Hollow pedestals, placed in the entrance lobby, and on each side of the pulpit stairs, supplied with steam, may be used with decided advantage, and may be made highly ornamental. Local circumstances will vary the placing of the pipes: it is for the practical man, taking advantage of the rules and suggestions we have given him, to consider the best means of applying them, and carrying them efficiently into effect.

We have been thus particular in describing heating by steam, as all the rules and calculations given are applicable in every respect to the hot-water system: the only thing different in the calculations is, that, in the rule given for ascertaining the surface of pipe, the mean temperature must be altered; for steam it is given as 200°—for the hot-water pipes, 140° may be taken as a safe approximation. (See Chapter IV., page 102.)

In the warming of dwelling-houses, where the apartments are supplied with air from the central staircase or hall, the most simple and obvious mode of proceeding is to have a properly constructed apparatus placed in the hall, sufficient to heat all the air supplied to the interior. A series of small pipes may be arranged in the inside of a handsomely designed table or pedestal, with open fretwork sides; or neat pedestals, or even statues, may be connected with the hot-water boiler, which should be placed in an apartment at the basement of the building. The modes and forms by which hot-water apparatus can be made effectual, are numerous—in fact, varying with the local circumstances of the place, from the plainest form or combination of circular pipe, to the handsomest and most elaborate decorative design. The principle in all cases is the same, the modes in which it is employed only differing. The heat from a gas jet, or rather a well-arranged series of gas jets, may be rendered capable of keeping up the requisite degree of heat in the liquid of a small range of pipe, or pedestal. A very handsome form, in which this might be adopted, is one of the many varieties of vases. Each separate apartment, in a well-arranged structure, should be heated by a pipe passing along behind the skirting which supplies the fresh air; or if the supply is taken, as we have noticed previously, to the centre of the room, a circular range of pipes should be taken there. In leading hot-water pipes to the various apartments, those parts not required to give out heat should be carefully covered with non-conducting material. A study or other apartment may be effectually heated, by leading the pipes to a handsome pedestal placed on the hearth, the surface of which would be gently heated by the pipes within; or the diameter of outside case might be made greater than that of the congerie of pipes in the interior: if left open at bottom or top, a current of cold air will enter at the bottom, and, impinging upon and passing through between the congerie of pipes in the interior, it will escape at the top, with its temperature considerably heated. A register-valve at the top may be used to regulate the ascent, or stop it altogether—the heat being then only given out by passing through the outside casing. As we have before said, the application of hot water to the heating of halls, apartments, &c., large or small, can be carried into effect by a series of almost endless devices.

In cases where heating rooms by pipes is not approved of, we would recommend the heat of the fireplace to be used in the manner recommended by Mr Hosking, the flues supplying the fresh air to be passed near the warm portions of brick, stone, or iron work surrounding the grate, so as to heat it before it issues into the apartment.

As a very efficient mode of taking advantage of the heated surfaces surrounding fire-grates, we give the following suggestions from the work of a very old author, who wrote on the proper construction of fireplaces considerably more than a hundred years ago. We give the extract as it stands in his work. The practical man will have no difficulty in taking advantage of the hints thrown out, excellent as they really are. "We suppose the whole compass of the inside of the chimney (the back part of the grate) covered with a plate of iron, brass, or copper, and behind it a void space about 4 inches deep, divided by several partitions, which form several cavities, cells, or square tubes—the first communicating with the second, the second with the third, and so on, making altogether, as it were, a sort of recurved canal, one of whose ends must be at the bottom and the other at top of one of the jambs, coming out into the room, so that the air can go in at the lower, and go out at the upper end of it. We may also suppose the under part of the hearth hollow, and covered with plate iron—nay, and the under part of the chimney-piece likewise hollow, like a pipe, so that all the cavities behind the back, jambs, under the hearth and chimney-piece, altogether, make forementioned winding passage. Now, supposing this passage for the air behind the chimney, as soon as a fire is made, it will warm the whole compass of the chimney, the hollow under the hearth, and the bottom and back of the passage under the mantel-tree, (if there is one,) and consequently the air within the hollows that those surfaces shut up, and the cold air which will come at the lower entrance, will begin to grow warm in the first cavity; then, as it comes through the second, its heat will increase; still it will grow hotter in passing through the third, &c., so that it will come out very warm through the upper hole. As long as there is any fire in the room, there will, by this means, be a constant circulation of the air through these hollows. . . . . . If the outward air be brought into the cavities behind the chimney, (grate,) by carrying on a communication from the lower hole quite out of the house, the room may also be warmed sooner, as well as to better purpose, than when we only cause the air in the room to circulate: a great quantity will then go out in the same time through the upper hole, because it goes quicker, as it is always more pressed from without than from within the chamber." It will be perceived that drawing the supply of fresh air from the external atmosphere is the better mode of proceeding; and the flow of warm air into the room may be regulated by a damper or valve placed at the entrance of the fresh-air ventiduct, where it joins the cavity behind the grate: of course, the greater the velocity of the current through the cavity, the less will the air be heated, so that, by regulating the admission of fresh air, any degree of heat may be attained.

We are well aware of the prejudice, almost universally existing in Great Britain, in favour of open fireplaces, and we must confess to our approval of its avowedly cheerful and comfortable (according to the English sense of the term) appearance; but we cannot, at the same time, be blind to its great faults, the chief of which is its unequal heating powers. Foreigners justly complain that, in our apartments, "one side is starved, the other roasted." Now this might easily be obviated by combining heating by pipes and by the open fireplace—retaining the cheerful blaze of the one, warming by radiation, and having also the efficient heating of the other, by pipes warming chiefly by contact. This plan of combination has advantages too obvious to be mentioned here—one, decidedly of great importance, being the doing away with the necessity of a large scorching fire, which, as our old author, already quoted, quaintly observes, "dries up the lungs and ruins the eyes, as may be perceived by their pain and redness; *spoils the delicate skin of the ladies*, hurts the eyelids, and destroys the finest complexions."

We are aware that, in recommending the adoption of the more scientific plans we have mentioned, to secure healthy and equable warmth in our apartments, we have to struggle against the prejudices of the great majority of people, as to what they are pleased to term "new-fangled notions." But we are convinced that, if our plans and suggestions are adopted in any one case, the advantages will be so striking and satisfactory, that their adoption will be considered by many. No improvements, in any department of science, have ever yet been introduced without difficulty and opposition; but by degrees public attention has been directed to them, and their adoption gradually become general. And so it has been with the important improvements we have noticed and commented upon; several of them have been promulgated years ago, yet it is only very recently that they have been adopted: we are content, in the mean time, to add our quota to the amount of information diffused, trusting that our practical hints will be found somewhat useful, in proving how easily they can be carried into effect. As to these "new-fangled notions" of the present day, what will the disciples of the "stand-still" school say to the following exposition of a plan, promulgated by our old author so many years ago, by which the useful effect of heated air is carried to an extreme that even our most enthusiastic ventilators would never dream of—and yet there is positively nothing absurd in the idea—it could be efficiently and usefully carried into effect: "If any one would have the warm air that comes into the room (by the plan we have already explained) to fall with all its heat on their hands or feet, to warm them in a little time, and keep them warm at any distance from the fire, they may easily do it, by setting one end of a tin or pasteboard pipe at the upper hole, where the warm air comes in, and the other end near the part which they would warm. Such a pipe may *be carried into a bed*, and warm it to any degree, by discharging its heated air into it; and as such a tube takes up but little room, the bed may be warmed whilst anybody is in it; and the warm air may be thrown upon any part of the body, so as to warm it as long as you please—which will be of great use, especially in some distempers, where it is required to apply warm napkins constantly to a patient. Those that can get no heat in bed, in hard winters, may be thus warmed."

We would here particularly warn churchwardens, and proprietors of public buildings, against the dangerous practice of heating by means of hot-air cockles, high-temperature stoves, &c. We do not know of a single instance where a church has been burned, but the cause could be traced to an old-fashioned defective stove. Let those using such consider, that heated air projected against any combustible, predisposes it to catch fire easily; and if the air is heated to a great degree, the combustible will be charred, and most assuredly set fire to. Let it be remembered that lead may be melted instantaneously by being subjected to the current of warm air produced in a cockle exactly similar to those used too frequently in many churches, &c.—that wood, nay, coals, can be almost instantly ignited by similar currents—and it will be perceived that the danger of such contrivances is very great: that, in truth, each time the building is heated by such, the risk is run of setting the place on fire, more especially if the heated air be supplied by pipes running near to, or in contact with, wood work. We have only, in corroboration of our remarks, to point to the burning of the Greyfriars' church in Edinburgh, and that of All-Saints in Manchester, both of which originated in the heated air from the stoves igniting the wood work. We are aware that the expense of fitting up hot-water pipes is greater than for common stoves, but surely the common rules of prudence and worldly wisdom will convince the proprietors of public buildings, that there is no saving in fitting up contrivances which may set fire to the structures in which they are placed, each time they are used. By a properly constructed "low-temperature" hot-water apparatus, it is a perfect impossibility to heat any combustible to ignition.

Construction of Fireplaces.—Without stopping to enter into an inquiry as to the antiquity of chimneys, or when they were first used, interesting as such would undoubtedly be, we will at once proceed to give practical hints for their improvement. We will first consider the position of the grate—mode of forming the covings or sides—and height and diameter of chimney flue. The object, in all ordinary grates, is to heat the floor: "if this be accomplished, it moderates the severity of the cold air there, and the upper portion of the apartment is warmed by the ascending currents that are immediately developed." The bars should be made as light as possible, as it is evident, the heat being radiated from the burning surface, heavy bars, covering a large portion, must prevent it. It is only when substances are red-hot that they shed out much radiant heat—the importance will be seen, then, of having the fuel burning as clear as possible. To insure this, the fire should be surrounded, on three sides, by slow conductors of heat. The plan, too often carried into effect, of having the whole body of the grate made of iron, is very erroneous in principle, as it is evident that so much of the heat will be withdrawn, that the fuel will burn dull and dead. Fire-brick is now becoming more generally used to surround the place where the fuel rests: it would be well if all manufacturers of grates would be convinced of the advantages to be derived from such a plan. The more surface of burning fuel obtained, the more heat will be sent into the room: to effect this, and at the same time to obviate the necessity of having a large and expensive body of fuel, the back of the grate should be provided with a projection in the centre, coming forward into the body of the fire, till within nearly three inches of the front bars—this should be larger at the base, where it joins the back, than at the front. It may be made of fire-brick, and should be firmly built in with the rest of the back. This is highly recommended by Mr Tredgold. As to the proportions for the front of the grate, Mr Tredgold says, that "if the length of the front of the grate be made one inch for each foot in length of the room, and the depth of the front be half an inch for each foot in breadth of the room, the proportions will be found tolerably near the truth, in the cases usually occurring in practice."

In the construction of fireplaces, the mode of forming the covings is of the utmost importance; And here let us stop to examine under what form the heat generated in the combustion of the fuel exists, and how it is communicated to those bodies which are heated by it. We have in some measure considered this, but as it will enable the practical man to perceive the advantages of the suggestions we will hereafter give, we deem it necessary here more fully to enter into it; and, in doing so, we cannot do better than give the following extract from Count Rumford's treatise:—"It is quite certain that the heat which is generated in the combustion of the fuel, exists under two perfectly distinct and very different forms. One part of it is combined with the smoke, vapour, and heated air which rise from the burning fuel, and goes off with them into the upper regions of the atmosphere; while the other part, which appears to be uncombined, . . . is sent off from the fire in rays in all possible directions. . . . It is highly probable that the *combined heat* can only be communicated by actual contact with the body with which it is combined; and, with regard to the rays which are sent off by burning fuel, it is certain that they communicate or generate heat only *when* and *where* they are stopped and absorbed. In passing through air which is transparent, they certainly do not communicate any heat to it; and it seems highly probable that they do not communicate heat to solid bodies by which they are reflected. . . . A question which naturally presents itself here, is what proportion does the radiant heat bear to the combined heat? Though that point has not yet been determined with any considerable degree of precision, it is however quite certain, that the quantity of heat which goes off combined with the smoke, vapour, and heated air, is much more considerable—perhaps three or four times greater, at least—than that which is sent off from the fire in rays. And yet, small as the quantity is of this radiant heat, it is the only part of the heat, generated in the combustion of fuel burnt in an open fireplace, which is ever employed in heating a room." It becomes, then, of "much importance to determine how the greatest quantity of it may be generated in the combustion of the fuel, and how the *greatest proportion possible of that generated may be brought into the room.*" We have previously shown that, when the fuel burns clearest, the most radiant heat is sent into the room; and also that, by a greater surface of red-hot fuel, the same effect will be obtained. It will be seen then, in reference to this point, that the common practice of heaping on coals, and smothering up the fire, is the very way to render the combustion of the fuel least effective in heating the room. On this point Count Rumford remarks,—"Nothing can be more perfectly void of common sense, and wasteful and slovenly at the same time, than the manner in which chimney fires . . . are commonly managed by servants. They throw on a load of coals at once, through which the flame is hours in making its way; and frequently it is not without much trouble that the fire is prevented from going out. As the rays," continues our author, "which are thrown off from burning fuel have this property, in common with light, that they generate only *when* and *where* they are stopped or absorbed, and also in being capable of being reflected, without generating heat, at the surfaces of various bodies, the knowledge of these properties will enable us to take measures, with the utmost certainty, for producing the effect required—that is to say, for bringing as much radiant heat as possible into the room." To insure this being effectually done, the sides or covings should be made so that the rays will be reflected into the room. Guager, in his *Fires Improved*, published in France in 1713, (translated by the celebrated Dr Desaguliers, and published in London in 1716,) and from which we have already quoted, was the first to demonstrate, that fireplaces with sides perpendicular, or at right angles to the back, were very ill calculated to throw the rays of heat into the room; and he clearly proved that the parabolic curve was best adapted for the purpose. This, however, is difficult for most workmen to describe: and Count Rumford proved that the fireplaces with the sides forming an angle of 135° with the back, threw the heat effectually into the room. This is a form easily made, and he describes it as follows,—" The best form for the vertical sides of a fireplace, or the coverings, (covings,) as they are called, is that of an upright plane, making an angle with the plane of the back of the fireplace of about 135°. To have a clear and perfect idea of the alterations, . . . the reader need only observe that, whereas the backs of fireplaces, as they are now commonly constructed, are as wide as the opening of the fireplace in front—and the sides of it are of course perpendicular to it, and parallel to each other—in the fireplaces I recommend, the back is only about *one-third* of the width of the opening of the fireplace in front, and, consequently, the two sides or coverings of the fireplace, instead of being perpendicular to the back, are inclined to it at an angle of about 135°."

Tredgold recommends the covings to form an angle of 45° with the line of the front bars of the grate; but, to insure the full effect of these reflecting surfaces, they *must* be made capable of reflecting the chief part of the heat which they receive. We have shown, in the first part of this Chapter, that " polished metals are bad absorbers of radiant heat, but powerful reflectors, throwing back a large portion of any radiant heat that falls upon them." The covings should be made, then, of plates of polished metal, to insure the full effect of the angular surfaces: these are, however, difficult to be kept clean and bright; other materials may be substituted. The best we can recommend is highly glazed earthenware, of a cream-coloured hue, as white is not very agreeable to the eyes; or a light blue or delicate green: the nearer, however, it approaches to white, it will be better. Backs and sides of grates might be made highly ornamental, by the adoption of elegant designs in this material. For cheap reflectors, the covings should be smoothly plastered, and painted white—never, in any instance, allowing them to be painted black. Though this is the colour generally seen, it is the very worst possible to be used. The next thing to be considered is the construction of chimneys.

"Chimneys," says Dr Arnott, "quicken the ascent of hot air, by keeping a large quantity of it together. A column of 2 feet high rises with twice as much force as a column of 1 foot, and so on in proportion for all other lengths. . . . . In a chimney, 1 foot in height of the column of hot air, may be 1 ounce lighter than the same bulk of the external cold air; and if the chimney be 100 feet high, the air or smoke in it is propelled upwards with a force of 100 ounces. In all cases, therefore, the draught, as it is called, of a chimney is proportioned to its length." As slow combustion is more favourable for throwing off radiant heat, the draught of the chimney should not be so great as to make the combustion rapid, neither should it be so feeble as to keep a dull fire, and be easily forced down by adverse currents. Very little attention has been paid to the proper construction of chimney flues: they are generally made at hap-hazard, and bear no proportion to the size of grate they have to draw the smoke from. Mr Tredgold gives, from deductions made by him, the following rule, which gives the area of size at top, which should be increased a very little at the bottom, near the fireplace. "Let seventeen times the length of the grate, in inches, be divided by the square root of the height of the chimney in feet, and the quotient is the area for the aperture at the top of the chimney in inches." All chimney-flues, in newly-constructed buildings, should be made circular: the advantages of such a mode are so obvious that they need not here be commented upon. Earthenware tubes are now made of all diameters, and are admirably adapted for the inside of chimney-flues. Those made by Doulton of St Helen's, Lancashire, for drainage purposes, would do admirably. We have stated above that the mouth of the chimney-flue should be of a little larger diameter than that of the top, but if made of the same size it will be sufficient. There should, if possible, be no bendings in its course: if these are necessary, from local circumstances, they should invariably be made with easy curves. The earthenware tubes referred to can be had with curves of every radius used. The openings of the flue should be made right above the mass of burning fuel, that the ascent of heated air and smoke may be in a perpendicular direction. A writer on the subject recommends the sides and back of the grate, after a certain perpendicular height, to slope or bend "inwards, from all points, immediately on reaching the height of the lower edge of the mantel, only so as to avoid acute corners, so that the insertion of the vent into it at the throat may resemble the insertion of the tube of a funnel into its mouth, or that of a stove-pipe into its fireplace." This is an admirable idea; but, in carrying it out, care should be taken, if the bent parts are made of iron, to cover them on the wrong side with a thick coat of plaster, to prevent the loss of heat by conduction; and that the inside, above the fire, be polished, or at least whitened, to reflect the rays of heat from its surface. The same writer who gives this plan also recommends the circular chimneys, but, unfortunately, he advises them to be made with the diameter gradually *increasing* towards the top. The reason he gives for this recommendation is, that, as the heated air and smoke rises in the chimney, there will be a proportionate decrease of temperature, "and, consequently, a sort of accumulation and thickening of the smoke will take place in the upper end of the vent—at least, where it does not widen gradually, there will be such a tendency, though the effect may be prevented by the vent being in every other respect properly constructed. But if such a chimney be disadvantageously situated, where the wind bears down into it from causes hereafter to be noticed, it will give way to the wind, and the smoke will be forced down into the room, which would not take place were the vent constructed on the principle of gradual expansion. *By this principle, the tendency of the smoke to accumulate will be relieved by the column finding more room as it advances*, in proportion as it falls off in velocity." The statement made by this writer, that the heated air falls off in velocity as it ascends the chimney, is perfectly correct; but he seems to have forgot that the philosophical way of increasing the velocity was by diminishing the aperture—just as we find that, when a river is confined within narrow banks, it runs with great velocity, while the same water, spread over a wide surface, is scarcely seen to move at all. The proportion for the height of the opening of a fireplace—that is, from the hearth to the foot of the mantel-tree—seems to be one-third of the height of the floor from the ceiling. This may appear inelegant, but the above writer says he has found it, in his practice, to be a safe proportion.

We have given in a former part of this Chapter a description of a grate, by which the effects of combined heat may be made useful; care should be taken to have the canals completely closed from all communication with the chimney flue. (See page 140.)

In constructing chimney fireplaces, the greatest care should be taken to prevent wood-work having contact with any parts of the construction; important as this is, we regret to say that no great degree of attention is ever paid to it. The utmost carelessness is displayed in the filling up of the back parts of grates—shavings, pieces of wood, are often found to be promiscuously shoved in. Every part should be tightly cemented, or at least well plastered, so that there can be no lodgment of soot in any part. We feel convinced that nine out of every ten cases of fire originate in, or about the fire-places—the fire communicating, in some one of the numerous ways too often left for it, with the combustible materials around the grate or chimney. Care should be taken in cleaning chimneys—the heavy lumbering contrivances should never be adopted; we think we are warranted in saying that the broom and rope used in Scotland will be found as effectual as any other.

"Were proprietors of houses," says a writer, "intended to be let, to place fixture grates in them at first, when they would be set, free of any of these combustible materials, and more substantial; much risk would be avoided; besides the destruction of paper, paint, and plaster occasioned by tearing out of grates, and putting in others of different construction. While an annual source of destruction and danger to the landlord's property would thus be done away with, a large yearly expense would be saved to the tenant, who would live in greater security from danger by fire." These remarks are more applicable to the condition of matters in Scotland, the tenants having in nearly all cases to supply themselves with grates. On this very important point we cannot refrain from giving the following long extract, from a work by Mr Beaumont of London, entitled, *Hints on preventing Damage by Fire*, convinced that our readers will derive considerable benefit from its perusal: "One of the most fruitful sources of accidents in common buildings in the country is—a beam of wood for the chimney breast: this ought always to be of iron. . . . Then, as if courting conflagration, timbers are laid close to flues, and sometimes even *within the flue itself*. . . Trimmers, joists, rafters, and girders protruded through the sides of flues, and even when lodged against the sides of flues, occasion numerous accidents. . . . The danger from fire, and the instability of brick-work are greatly increased by a practice, among scamping workmen, of leaving hollow places called pockets in their walls, and in using only so much mortar, in laying their bricks, as give a fair joint to the eye, leaving all behind hollow. The hollows get filled with soot; and when a fire takes place in an adjoining flue, the sooty chinks form a train which sets the building on fire. . . A minor cause of alarm sometimes arises from the setting of block chimney-pieces in such a manner as to have a communication between the hollow of the chimney-piece and the flue, in which hollow the soot gathers, and at length takes fire; but a more frequent cause, of the same kind, consists in the grate being set hollow behind. In this receptacle the soot falls and collects for a length of time, until it reaches the middle of the grate, when, upon the back becoming red-hot, it lights the heap, and produces such an intense fire as to endanger the adjacent wood-work. . . . Firing from alterations in flues, and additional flues erected in old buildings, are very common. The workmen must be, of necessity, somewhat in the dark as to the precise layings of adjacent timbers; but the indifference with which they disregard the contiguity of timber, which they see or know off, is frequently remarkable. . . . Iron stoves set on a wood floor, and having iron pipes, are always more or less dangerous. It is thought enough to have a sheet-iron fender to set the stove upon, but more is necessary to be secure. Iron pipes to these stoves are full of danger; when they are not in use, particularly if there be much soot left in them, they collect moisture and are rapidly oxidised. Then, when they become filled with soot, and the soot takes fire, it burns fiercely; and the fire drops through the rust holes and the joints, and if these droppings occur between a wainscoting, or a battening, and a wall, at the hole where the pipe enters the brick flue, it is likely to set the house on fire. The danger is more imminent if the pipe passes through a floor, or lath and plaster partition."

Smoky Chimneys.—A smoky chimney has been well characterised as one of the most annoying of our house discomforts. Annoying as it undoubtedly is, it is matter of astonishment that, with one or too solitary exceptions, no really successful remedy has ever been applied to overcome it. However, our surprise may be considerably lessened, when we consider that the generality of individuals who have directed their attention to the subject, have been utterly ignorant of the philosophical laws which regulate the movement of heated air. Neglecting, or entirely overlooking the study of these, they have depended upon various plans and machines for effecting a cure, the most of which have been constructed in complete defiance of all natural laws. It certainly is matter of regret, that scientific men should have so long considered this subject beneath their notice. We free them from the imputation of inability to cope with its difficulties, but we blame them for their indifference; more especially as, by turning their attention to the subject, they would not have compromised their professional dignity, which, we suspect, they were afraid of doing. Of late years, however, we have seen engineers and scientific men, high in their respective professions, who have not thought it unworthy of their special attention. This has resulted, fortunately, in making known very many valuable suggestions, scattered here and there, through the records of their experience and experiments: these, in the course of our own remarks, we intend to present to the reader, nothing doubting but that he will derive much information, of high practical value, therefrom.

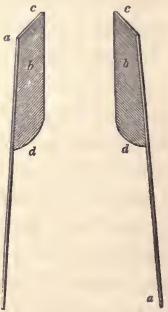
"In the Vespæ," says Beckmann, in his *History of Discoveries*, "of Aristophanes, old Philocleon wishes to escape through the chimney. Some one asks, 'What is that which makes such a noise in the chimney?' 'I am the smoke,' says the old man, '*and am endeavouring to get out at the chimney.*'" If the smoke in the chimneys of our day were thus gifted with the power of speech, how many would tell the same tale? very probably, nine out of ten are so badly constructed that it really always is an endeavour, on the part of the smoke, to escape from them. Now, as the natural course of heated air is upwards, there must be something very materially wrong in the construction of chimneys, when the smoke is prevented from easily ascending. The idea that generally obtains, that smoke is really lighter than air, is very erroneous; in reality, it is the converse: "it consists," says Dr Arnott, "of all the dust and visible particles of the fuel, without being burned, and are, moreover, light and minute enough to be carried aloft by the rising current of heated air; but all that is visible of smoke is really heavier than air, and soon falls again, as powdered chalk in water. In the receiver of an air-pump, where a candle has been extinguished by exhausting the air, the stream of smoke that continues to pour from the wick, after the exhausting, is seen to fall on the pump-plate, because there is no air to support it. A familiar illustration of this truth, may be seen in close days, when the smoke hardly ascends, when the air, within the very zone of respiration, is full of smoke, surcharged with smutty particles. The air is so rare and light, that it cannot support the heavy particles of the smoke—they consequently fall to the ground; hence may be seen the absurdity of the popular opinion, that the air on these occasions is so *heavy*, while, in fact, it is the very reverse. It will thus be seen, how the visible part of smoke ascends merely as it is mixed with the heated air, the products of combustion, of which it forms a part. If the reader has sufficiently attended to our remarks, at the commencement of this treatise, he will understand how the heated air is pushed upwards by the colder and denser air, at the bottom; and that, unless a supply of cold or dense air is kept up below, no upward current can possibly take place. Now we humbly conceive that, in the proper application of this natural law, lies the key to the solution of the difficulty of curing smoky chimneys. That the reader may fully understand what we mean, we here put it specifically,—*Heated air cannot ascend a flue, or chimney, with force sufficient to overcome opposing currents, unless a due supply of fresh and denser air is supplied below, at or near to the fireplace.* Now the result of all experience goes to prove the *axiomatic* truth of this, independent of its theoretical accuracy. In every work we have studied—and to almost every one worthy of notice have we referred—this is stated as a decided principle; and our own experience has invariably given satisfactory proof of its accuracy. Guager, in his work, (1713,) gives a plan for supplying fresh air near to the fireplace, exactly similar to the one we have seen adopted with much success, before ever we heard of his book: it consists of an aperture in the hearthstone, connected with a ventiduct, or air channel, leading to the external atmosphere—Dr Franklin says,—" Smoky chimneys in a new house are such, frequently, from mere want of air." Silver, in his treatise on smoky chimneys, says that the two points, on the knowledge of which the adopting of proper remedies for smoky chimneys will materially depend, are,—" First, that a constant and proportionate supply of cold air, is necessary to supply the place of the heated air, continually passing up the vent; and, second, that it is from the lower part of the apartment the supply will (ought to) be chiefly derived. Dr Arnott says, " Perhaps the best method of admitting air, to feed the fires, is through tubes leading directly from the outer air to the fireplace." And Dr Reid says, " Nothing is so common a cause of smoke, as an insufficiency in the amount of air supplied to any apartment.

By having the flues and fireplaces constructed according to the rules and suggestions we previously explained, by supplying a due amount of fresh air to the fireplace below, no chimney will smoke. On the other hand, we do not hesitate to say, that, however well arranged and constructed the flues and fireplaces are, if not supplied with a proper amount of air, they will inevitably smoke. So unvarying in its action is the law we have noticed, in its operation, that, whenever a chimney smokes, we may rest assured that the supply of air below is deficient—that some opposing current has overpowered the ascending smoke and heated air. We do not remember of ever seeing a case in which the opening of a door or window did not restore the *natural* current, and cure the smoke. Had the course of the air admitted by the door or window been traced, it would, in every case, without exception, have been found making directly to the fireplace. Many rooms smoke, on account of the air therein being drawn away to supply a larger fire in another apartment, not properly supplied with air. Were the two rooms supplied, independently of each other, with a sufficiency of air, the chimneys in both rooms would draw well, without smoking. We know of one instance in which almost all the chimneys in one house smoked; the course of the current was examined, and it was found that a large stove in the laundry actually drew its supply of air from the fires below, through the medium of the staircase. The laundry, situated above, after this, being well supplied with air, the other chimneys ordinarily drew well. Large kitchen fires frequently draw their supply from other apartments, causing these to smoke, if fires are lighted in them. A fire which has been in operation all day in a sitting-room, in the same floor with a drawing-room, has overpowered the newly kindled fire in the latter; by drawing the air therefrom for its own supply, the newly assembled visitors have been obliged to vacate the apartment. A person at all acquainted with the subject would have at once discovered the cause, and, by the opening of a window in the sitting-room, through which a supply of air could have been obtained, independent of the drawing-room, the difficulty would at once have been obviated. In this case, the sitting-room, when its windows were shut, habitually drew its supply from the drawing-room. A large drawing-room, with all the appliances to insure what is deemed comfort—namely, tight-fitting doors and felted windows—was heated by two fireplaces, one at each end of the apartment. One grate was larger than the other; when in full action, it drew its supply of air from the flue of the small fireplace—the smoke, of course, descending to the room; when the fire in the small grate was in full force, and that in the large feeble, the action above explained was reversed. This amusing but disagreeable state of affairs could have been at once obviated, by giving each a supply of fresh air. We could cite numerous examples of the truth of the principle we have enunciated, but we do not consider it at all necessary. Having drawn *general* attention to the fact, we doubt not that all observations hereafter made will corroborate its truth.

The course of the current in a smoky room must be found, in applying the principle to cure it. This will best be done by a small lighted taper, or a small piece of smouldering brown paper, emitting smoke. By holding this quietly in the room, the direction the flame or vapour takes is that of the current of air; if it leads to a stronger fire in another apartment, rest assured this derives its supply from the room smoking. Supply the room with the strong fireplace with air. To every room in a house would we recommend the following plan to be carried into effect, whether such rooms be smoky or not —whether they smoke by supplying fires in other apartments, or by opposing currents, caused by winds forced down the chimney. From the open air lead a pipe, varying in size according to the size of room or grate, (not less than two inches for a bedroom grate,) from a hole made in the wall to the space beneath the hearthstone, immediately below the place where the fender usually stands; let an orifice be made in the hearthstone, above the termination of the fresh air pipe—covered, if so wished, with a small iron grating; let a few apertures, equal in area to that of the aperture, be made in the fender, above the aperture—or louvre-shaped openings may be substituted in place of the holes, to prevent dust and ashes going into the air aperture in the hearthstone. The ventiduct thus made should in all cases be supplied with a valve to regulate the admission of the air. The ventilating grate, recommended by William Hosking, Esq., previously mentioned, may be used with advantage, instead of the plan we have here given—ours is much more simple, and will be more easily carried into effect. Better err in making the supply of air too large than too small; the fire will take no more air than it actually requires.

The air channel thus recommended, serves another important purpose, which must not be omitted to be noticed here—"it leaves the apartment free from many of those draughts and currents that are common to all ordinary rooms with fires, and which pass in general between the window and the fireplace, or the door and the fireplace." In some instances the air is supplied at the back of the grate, beneath the bars; but we approve of the plan of having the aperture at the front, so that the air will be thrown upwards, where most required, without meeting with opposing surfaces.

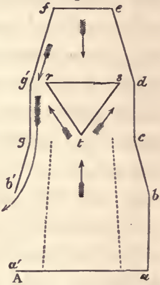
Chimneys, when made very wide at their orifices, or throughout the length of the flue, are predisposed to smoke. In such cases the heated air is often found to be ascending by one side, while the fresh air is actually coming down the other to supply the fire—consequently, the ascending column of heated air being considerably cooled, any opposing current has a great effect in relaxing it. Hence, such chimneys frequently smoke in high winds. It is evident that, by adopting the plan we have proposed, there will be no necessity for a downward current of air through the chimney, sufficiency of air being supplied below. But, in all cases, the apertures for the egress of the smoke should not be larger than is absolutely required. We have before given a rule to find the size in newly constructed chimneys—it is applicable in cases where the degree of contraction is required to be found for wide chimneys already made. A practice obtains amongst many practitioners, of contracting the orifice of the chimney at the bottom, nearest the fireplace. "It is like," says Tredgold, "contracting the aperture which supplies a jet." This is a much disputed point, almost all practitioners contracting the orifice at the bottom. Clauvelin and Gilbert have, however, demonstrated the advantage of contracting at the top. We have already noticed one good effect of this mode—namely, increasing the velocity of the heated air just at the place where, from its decreased temperature, it is most required. It is best to have the flue of the chimney of equal dimensions throughout, the bottom being a little larger than the top, if conveniently made this way. It is undoubtedly a good plan to contract a wide chimney near the fireplace, even were it for nothing else than the prevention of eddies and currents, which would otherwise be created; but it will, moreover, by increasing the velocity of the current, be of material advantage in assisting the upward current. But, in all cases, the top should also be contracted. After finding the area of the proper aperture, after contraction, by the rule previously given, (see page 152,) the following plan should be adopted—*a a* the chimney-pot, *b b* the iron part for contracting. The bottom part should be rounded as at *d d*, the parts *c c* should be made angular, as shown—the angular faces very much facilitating the passing of the wind over them. The parts *b b* may be made of Roman cement with advantage,



as the heat of the smoke will not be conducted, as would be the case with the iron; or, if made of iron, their interstices might be filled up with non-conducting material.

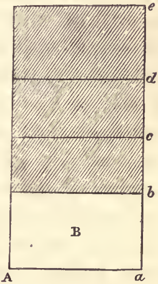
Some chimneys draw well in calm weather, and in certain high winds; but with some particular wind, whether strong or moderate, they smoke very badly, in proportion to the strength of the breeze. As the smoke in these cases is occasioned by the wind either striking on some adjacent building or eminence, or from some local peculiarity of the orifice of the chimney, it is necessary to provide "tops" on the outside, to prevent the down-draughts which are thus occasioned—these being in some cases so strong as to overpower even the *best* regulated currents of heated air in the chimney flue. The tops used in such cases are so designed that the apertures for the escape of the smoke are either always turned away from the wind, (by the force of the wind itself,) as in the common revolving ventilator or cowl; or the apertures are arranged and commanded by well-designed covers, so that it is impossible for the wind to blow down in any case. We would in all cases recommend fixed and permanent tops, instead of the movable caps or cowls, so generally used: they do not make any disagreeable noise, and last much longer. The top figured in Chapter II. may be adopted with success. As a really efficient cap, we can cordially recommend Kite's (of London) diamond-deflecting chimney-top: it is constructed on truly philosophical principles; and in every case where adopted, (the other parts of the chimney being properly constructed, and a good supply of air secured below,) it has given great satisfaction. It has been adopted by the honourable the Commissioners of Woods and Forests. As a top which cannot fail to be effectual, and down the chimneys on which it is placed the wind cannot possibly go, we give the following, taken from Guager's work previously alluded to. Fig 1. is a side elevation; cut out of a sheet of thin plate-iron a piece shaped as in the figure. The dimensions will vary, according to the size of the chimney ledge and orifice. The following will be found to be good proportions: If the base *A a* is 14 inches broad, let *a b* be 8 inches, *b c* 6 inches, and *e d* also 6 inches; the breadth *c g*, *d g'*, 12 inches—or 11 would be better, as more slope would thus be given to the part *c b*; *d e* 8 inches, and *e f* equal to the aperture of the mouth of the chimney, as found by the rule previously given. The common clay chimney can or top, as shown by the dotted lines, is placed on the aperture of the chimney. At the height, and on a line with *d g'*, draw the base of a triangle *r s*, 2 inches longer than the mouth *t* of the top; make the sides *r t*, *s t*, of length sufficient to make the apex *t* be in a line

Fig. 1.



with the aperture of the chimney-top: cut this out with a chisel, thus making a triangular opening. Having thus got one side, make another exactly similar, by laying this on a sheet of iron and tracing all round the edges, and thereafter cutting it out. Supposing the square of the chimney on which this top is to stand to be 14 inches, then these two ends are to be joined together by sides 14 inches long, on the parts *e d*, *d c*, *c b*, leaving the part *a' b* open. When the top is thus far completed, make a triangular prism of iron, or plate-iron, with the three sides firmly and neatly fastened together; this should be less than the hole *r s t*, cut in the ends, and 14½ inches long. Shove this through the apertures *r s t*, so that each end of the prism will rest upon the edges of the holes in the ends. The arrows will show how easily the smoke will gain egress; and how difficult it will be for the wind, even if blowing directly down, to enter the aperture of the chimney—indeed, when the chimney is in action, it will almost amount to an impossibility. Fig. 2 is a side view; *B* the open part, left uncovered on each side. (The same letters refer to both figures.)

Fig, 2.



Where the chimney only smokes in certain high winds, by what is called a blow-down, a well-constructed top, such as we have now described, will in some measure cure it; but all such contrivances will, in the generality of cases, be totally ineffectual, without a proper supply of fresh air is admitted to the fireplace below. We would, then, strongly recommend, in all attempts at curing smoky chimneys, to make this the first essential; and while doubtless improving the other parts, in accordance with our suggestions, to make such subordinate to, and as supporters of, the first great principle. We are decidedly of opinion that no chimney, however well constructed and provided with all appliances, will *draw* well, at *all* times, and under *all* circumstances, unless a due supply of fresh air is provided below; and that, for economy and certainty of success, the best mode of supplying that air is by leading it, in pipes or conduits, from the open air at once to the fireplace, so as to be independent of all other sources, even of air supplied to the apartments by well-devised and efficient ventilating contrivances.

RECAPITULATORY REMARKS

In ventilating public buildings, it should be borne in mind, that half-measures will not give satisfaction. Foul-air ventiducts, without provision being made for admission of fresh air, and *vice versâ*, will be totally ineffectual in ventilating the building efficiently. To obtain the full advantage of the plans we have explained, it is absolutely necessary to have the fresh and foul air ventiducts acting in concert—not independent of one another.

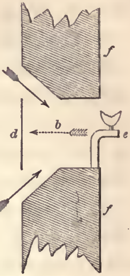
If the air at the bottom of the walls is impure, or liable to be mixed with dust, or other extraneous matter, the fresh-air ventiducts should be made in the interior of the walls, as shown in page 26. All fresh-air apertures, wherever made, should have their external mouths guarded with bars or large perforated zinc, (see p. 48,) and should be furnished with valves, to regulate the admission of the air, (see p. 28, 29.)

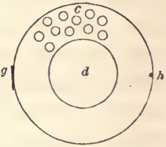
The foul-air ventiducts should be fixed at the highest part of the ceiling, (see p. 32,) and be provided with valves, (see p. 35, 36.) If the ventiduct should be of the second construction, (as shown in p. 36,) an ornamented board should be fixed beneath it, as there recommended. The ventiducts should be extended above the ridge of the roof, and properly finished at top, (see p. 41.) The galleries should be provided with separate fresh-air and foul-air ventiducts, (see p. 38.)

In theatres, hospitals, &c., where large foul-air ventiducts cannot be used in the central roof, it will be necessary to provide air channels in the side or end walls. These may be made similar to the plan described in page 26 — the aperture for the admission of the foul air being, of course, in the interior of the building, and as near the ceiling as possible; the aperture for its egress, made as described in pages 47, 48.

In ventilating private apartments, it is essential to have apertures for the ingress of fresh, and the egress of foul air, acting in concert. For the modes of admitting fresh air, see pages 64 to 68. In whatever way the fresh air is admitted, care must be taken to diffuse it before entering the apartment, (see p. 64—67.) For withdrawing the foul air, any of the modes proposed in Chapter III. may be adopted. One objection may be made to the tube described in page 73—namely, that, by projecting so far into the interior of the flue, it may be in the way when the chimney is being cleaned. This, however, may be obviated by putting the "cap" near the wall. The following are other plans: Let an aperture be made in the wall above the fireplace, near the ceiling, leading to the chimney. From this aperture a pipe may be led up the interior of the flue, close to the wall, and extended some twelve or eighteen inches *above* the external opening, or aperture of the chimney-can; and provided with a cap or top, to prevent the smoke being blown down. This contrivance will be thoroughly effectual. It bears a close resemblance to the syphon principle, yet is somewhat different: it will act best when there is a fire in the room. The annexed figures are explanatory of a room-ventilator, the invention of Mr William Bryden, of George Street, Edinburgh. In cases where the fireplace is well supplied with air, in the manner we have previously described, a more elegant, simple, and thoroughly efficient contrivance could not be adopted for the ventilation of private apartments. It is decidedly by far the best we have yet seen or examined. Of course, in fitting them up, every care should be taken to prevent blow-downs in the chimneys to which they are applied.

A hole *b* is cut in the wall near the ceiling, communicating with the chimney *f f*. Into this is inserted a tin or iron funnel, shaped as seen in the figure. At the large diameter of the ventilator, in the interior of the room, a lid or covering is placed, hinged at one side, as at *g*, and having on the opposite side a button or catch *h*, to keep the cover close. It should be made to fit very tightly. A part of the cover *d* is left solid, the diameter of this being equal to (or a little larger would be better) the diameter of the pipe *b* of the ventilator leading to the chimney. The other part of the cover, formed by the space within the two concentric circles, is punched with small holes, as shown partly at *c*. The surface of these must be equal to that of the pipe *b*. A glance at the topmost figure will at once explain the action of this ventilator. The upward current in the chimney-flue maintains a continual flow of air from the apartment, through the holes *c c*. If a blow-down is caused, the smoke, passing along the tube *b*, is thrown against the solid part *d*. Unless the blow-down is of very long continuance, the smoke is driven back into the chimney by the current through the apertures *c*. A gas jet, fixed at *e*, causes the current through the apertures to be much stronger. "The light





would be hidden, and would give no smell or annoyance whatever, and be applicable in summer, when a fire in the grate would be a nuisance." The "funnel ventilators" are made and fitted up at a moderate expense by Messrs William Bryden and Son, 55 George Street, Edinburgh, and by Mr A. W. Gilbody, 30 Bridge Street, Manchester, who also make the chimney-top figured in p. 170.

We have elsewhere specified fire-draught as being one of the modes of carrying out *artificial* ventilation, and, while recommending natural ventilation, of course, to a certain extent, disapproving of it. But we intended to do so merely in cases where large fires or furnaces were made and maintained *exclusively* for the creation of ventilating currents. Where the currents from fires are at hand, and made easily available, they should certainly be taken advantage of, and by no means allowed to remain useless. As an instance of a highly judicious appropriation of the power of a chimney-shaft, we may notice the plan adopted by Mr Fleming of Glasgow, in ventilating the pile of dwelling-houses known by the name of the *Barracks*. By leading the pipes along the passages (communicating with the various apartments) to the interior of a steam-engine funnel, the strong upward current withdraws the foul air most effectually. In such plans, care should be taken to supply plenty of fresh air to the apartments.

In ventilating the lights in any apartment, it should be remembered that the tubes for leading off the products of combustion will act most efficiently when the parts above the flame are bell or funnel mouthed. We have seen many tubes fitted up of the same diameter throughout—such diameter being very little larger than the extent of flame below it. That this is erroneous, any one acquainted with the principles of hydraulics, will at once perceive. And the flow of air through pipes very much resembles that of water: water flows much more rapidly through a pipe with a funnel-shaped mouth, than through the same pipe with no such provision. Moreover, it is evident that, where the mouth of the tube is equal to, or even a little larger than the spread of the flame, a slight draught of air will blow the products of combustion past the influence of the tube. If, however, a funnel is provided, such will be prevented. The size of funnel should be proportioned to that of the flame—at least twice the diameter. Thus, if the spread of flame is $2\frac{1}{2}$ inches, the inside diameter of the funnel should be at least 5 inches. In cases where the tubes leading off the products of combustion can be led at once through the roof, the power of the heated current can be made available, as an auxiliary to the ventilating arrangements otherwise adopted. In some cases, we have seen apertures made in the tube; through these a current of air was drawn from the room. When the tube is drawing very well, these may to a certain extent be useful; but the currents of air drawn in are very apt, by cooling the upward current of heated products, to lessen its ascending force. Again, where these apertures are near the ceiling, the heated products, when the draught in the tubes is slow, are often passed into the room. By adopting the plan we now recommend, the heated current will not be cooled by mixing with other currents from the room; neither will the products of combustion have any mode of egress, save by the aperture at the external atmosphere. Measure the distance from the edge of the funnel, when hanging at the elevation intended for it, to the under side of the ceiling through which it passes. One inch below this mark, pass round a tube surrounding the inner one, and leaving a space between the two, equal to one-fifth of the diameter of the inner tube. Carry this outer tube up to the elevation of the inner one, and provide a top covering both. Pass the tube through the aperture in the ceiling, and fasten it there. At the lower edge of the *outer* tube fasten a funnel mouth. It is easily seen how the inner tube will heat the air included between the two tubes, thus creating an upward current therein. The air near the ceiling will pass along the edge of the funnel, up the space, and be finally discharged into the air, at the same time with the products of the inner tube.

In cases where the tubes are led to openings in the back wall, (see p. 78,) if a tube is carried up the wall *d* for two or three yards, the current of heated air in the pipe *e e* will be materially assisted. This should be done in all possible cases, where the tubes are not taken at once to an up shaft, as a ventiduct or chimney flue.

In ventilating agricultural structures, care should be taken to have the amount of air supplied ample, (see p. 92 ;) and in the construction of drying-houses, a proper heating apparatus should be adopted from the very first.

In heating public and private apartments, all stoves should be discarded which are liable to get overheated—burning the air, and endangering the premises in which they are placed.* Hot-water

* We have elsewhere noticed the want of the common rules of prudence displayed by parties who fit up stoves in their premises. We had occasion to visit a warehouse a short time ago, in which we saw a huge square stove, with a fire burning furiously in it, some six or eight inches only from a wooden partition. The metal was fast becoming red hot. In strict justice, insurance offices should charge a double premium in such cases. We may draw attention to the awful fire in Piccadilly, Manchester, by which a splendid warehouse was totally consumed, with all its valuable contents. We will venture to say, that the fire originated through the medium of the stoves. Fire caused by such may smoulder a long time before finally breaking out. In this warehouse, hot-water pipes had been once in use, but were removed. Sad mistake ! At some future period we may return to the consideration of the proper construction of warehouses.

apparatus will be found to be the cheapest and most efficient. It should be borne in mind that no heating apparatus, however well arranged the parts may be, can give satisfaction, unless acting in a well-ventilated apartment.

In attemping to cure smoky chimneys, defective supplies of air to the apartments will be found to be the generally prevailing cause. Some flues may be too small to allow all the products of combustion to go easily off—this, however, will be an exception to the general rule. Chimneys are almost invariably too wide. If, however, they *are* too small, the only way to remedy the evil (save by taking down the flue and rebuilding it) is to lengthen the flue. This should be done with stone or brick, never in any case employing long tin or iron tubes, as is too often done. These being good conductors, the heated currents in them are rapidly cooled. If, however, iron tubes are considered cheapest, let the inner one be enclosed by an outer tube—leaving an inch or an inch and half space between them, which should be filled with non-conducting material, as lime, sand, horse-hair, animal charcoal, &c. Attention should be paid to the suggestions we have thrown out relative to the construction of fire-places and chimney-flues. If these are carried out along with good plans of ventilation, such as we have now described, there is no danger of being troubled with that domestic pest, a smoky chimney.

In conclusion, we trust that the remarks and suggestions we have offered in the course of our little work, will be the means of inducing more general attention to the important subject which we have treated. The Christian minister should remember that he has no right to expect his congregation to give lively attention to the subject on which he may be descanting, while they are subjected to the influence of an atmosphere, body and soul depressing, (see p. 43.) On the other hand, the congregation should not forget that it is in *their* power, almost solely, to remedy the evils to which they are exposed; and they ought to consider, that they cannot obtain the full force of their pastor's mental energy, when he is depressed and subdued by the poisonous atmosphere surrounding him.

With reference to the ventilation of workshops, &c., it would be well for employers to consider whether they are not acting upon erroneous principles, in subjecting the parties they employ, to influences which have a marked effect on the amount of labour done. It is a fact patent to all who have considered the subject, that by no possibility can a man working in a foul atmosphere give the same amount of labour that he would do if surrounded by pure air. By a simple statement of figures, we could make it abundantly evident, that the money lost to employers by this cause alone, amounts to a very considerable sum in the course of a year; but for the present we will enter no farther into details. Taking a moral view of the question, is it not notorious that tailors and others, who are subjected for hours together to an atmosphere that would kill birds submitted to it, rush, when their hours of labour are over, to scenes of dissipation and revelry —eager, in their pursuit of excitement, to relieve themselves of the oppression caused solely by the poisonous agent they were subjected to? We are convinced that a very great decrease in the amount of immorality would result from proper ventilating arrangements being adopted in all workshops. This may be considered by some to be an absurd statement, nevertheless it is amply borne out by the evidence and experience of those who have in any degree given their attention to the subject. It would be instructive to trace out the reason why certain trades are so notoriously dissipated. If we are not greatly mistaken, very curious information would be elicited in the course of the inquiry, tending to throw a new and important light upon the influence of impure air on the *morals* of man.

APPENDIX

VENTILATION OF SHIPS, STEAMBOATS, AND COACHES.

The amount of air generally supplied to the cabins and sleeping apartments of sailing vessels and steamboats is exceedingly defective. In steamboats, more especially, is the want of air particularly observable. The oily, heated air from the engines, the sickening smell from the bilge-water, all tend to increase the distressing tendency of the close confined air in the cabins, and to make the discomforts of a sea-voyage more oppressive—these in many cases being bad enough in their effects, without such disagreeable accessories. In the great majority of steamboats leaving our ports for short or comparatively long passages, there is no provision whatever made for the admission of fresh air, save the entrance to the cabin, and the skylight in the ceiling; yet these can only be used in calm or fair weather, (and in too many instances they are shut when they might be open;) so that the passengers, in stormy weather, when these are closed, might, with as much regard for their health, be placed under inverted air-tight domes. We feel convinced that the atmosphere, in the cabins of the majority of vessels, is creative of much disease, and many untimely deaths. How often do we see the sickly and delicate braving the most unpropitious weather on the open deck, rather than submit themselves to the body-and-soul-depressing influence of the poisonous atmosphere beneath !—and when at last forced to descend, what must be the effect of the foul air upon the delicate structure of the lungs, or the pain occasioned by violent sickness, likely brought on, or at least greatly aggravated in its effects, by the air with which they are surrounded ! In such cases, the costly decorations around them are viewed with indifference—nay, by many considered as if put there in mere mockery of their condition ; and with gladness would the most fastidious exchange all the splendour for a supply of pure and wholesome air. How absurd, then, does it appear, to hear of parties taking short or long trips by water, for the benefit of the change of air ! Undoubtedly they are surrounded by a pure and refreshing atmosphere, but every means are adopted to exclude it from the apartments beneath, in which much time must necessarily be spent. As if the desideratum was to supply the passengers with foul and contaminated, instead of pure and healthy air. It would be well for the proprietors to consider, whether a due regard to their own profits in their undertakings, independently of the justice done to the passengers they convey, would not make it a matter of some importance to ventilate their steamboats ; as it would probably tend to increase their profits, "by inducing many to take passages with comparative relief, upon which they would not otherwise venture, and as it is possible, by such means, to reduce very much the severity of sea-sickness, when its occurrence cannot be prevented." We have known instances where large sums of three and *five thousand* pounds have been expended upon the decorations of the cabins, yet not one halfpenny laid out in ventilation, so as to secure a proper supply of fresh air. We must not be supposed to deprecate the custom of decorating these places; on the contrary, we are strong advocates for the introduction of specimens of the "beautiful" in *all* places where human beings generally assemble; but we would certainly as strongly advocate the importance—nay, the paramount necessity—of appropriating some portion of expenses towards supplying the interiors of cabins with air.

Were the proprietors generally alive to the importance of the subject, and aware of the deleterious influence of foul air, we would be inclined to demand ventilating arrangements, in all ships and steam-vessels, as a right justly due to passengers—not to be begged for as a boon, to be conceded as a favour. But we are aware that great ignorance prevails amongst them on the subject; and we may rest assured that, once they are better informed as to its necessity, every vessel will be amply provided with proper means of supplying air. We sincerely hope that this necessary information will become generally disseminated, and that, independent of the removal of less startling and obtrusive evils, the public will not be shocked by the occurrence of such lamentable catastrophes as that of the "Londonderry" steamer—an accident which *may* happen on board almost every ship or steamboat carrying a large number of passengers.

In supplying air to the sleeping-berths and cabins of sailing vessels, the principal difficulty met with is obtaining apertures of sufficient area for the ingress of the fresh, and the egress of the foul air. In general, the only provision made to secure these, consists in the entrances to the companions or ladder-ways. When open, a current of air is observed passing downwards on one side, while, on the opposite side, an ascending current of foul air may be traced. These, however, are varying in their action, and cannot be depended upon, and in stormy weather are closed, and consequently not available. In some cases, air-channels, from the extreme value of space on board ship, cannot be made at all ; it is then necessary to provide, for ventilating purposes, some mechanical means, or the power of heat.

In providing air-channels, in cases where natural ventilation can be adopted, care should be taken not to mix the air supplied by them with that in the holds—that is, the holds and cabins should be supplied independently of each other. In leading fresh air to the cabins, it should be taken to a narrow opening running along the floor, within 8 or 12 inches of the fronts of the berths ; or, instead of a long slit, holes may be bored, some quarter of an inch in diameter. For leading away the foul air, the simplest mode will be to have, in a central place of the ceiling, a large opening, leading to a skylight or ornamental pedestal on deck. The sides of such might be supplied with louvre-shaped openings, through which the foul air might obtain egress, yet prevent rain or wind descending. It is obvious that a similar pedestal may be placed on deck, *down* which, by the disposition of the openings, fresh air may be supplied—air-channels made of tin tubes, communicating with the bottom of this, leading along the roof of the cabin, and down to the openings in the floor. These tubes may be covered externally with ornamental covers, or be altogether concealed in the beams, or divisions of the bulkheads. Or, if pedestals are objected to on deck, pipes might be fastened to the side of the stays or beams of the bulwarks on deck. These, open at top, and completely out of the reach of all harm, would supply a good amount of air, if led down through the deck, *the back* of the berths, and communicating with holes made, as before mentioned, in the floor of the cabin. From the local nature of the parts of a ship differing so much in different cases, it is almost impossible to lay down specific rules or suggestions for leading fresh air down to the cabins of vessels; but, the principles regulating the action of air being well studied, no shipwright can have the slightest difficulty in applying them, to insure efficient ventilation in any ship submitted to his notice. Being excluded from giving minute particular details, we must content ourselves with remarks of a general nature. For extracting the foul air from each *particular* sleeping-cabin, the application of the syphon principle, before explained, will be simple and effectual.

For supplying fresh air, the windsail is very frequently used. It is usually made of canvass, like a circular tube, with one side, or part of one side, open. This open side is turned towards the quarter from which the wind blows; a supply of fresh air is thus forced down to the interior of the cabin, generally through the skylight. This contrivance can only be used in calm weather—that is, when the wind does not blow violently—a certain degree of wind being necessary to insure its action. In thoroughly calm weather, it acts the part of a foul-air ventiduct, the fresh air being supplied by the doors. If made very large in diameter, there will be an ascending current of foul air up one side, while down the other there will be a descending one. It is obvious that the plan above mentioned, of having a pedestal on deck furnished with openings, down which the air can be forced, is merely a modification of the windsail, but constructed of permanent materials. We would strongly recommend shipowners to fix small permanent pedestals on deck; these would be no more in the way than skylights, and might be made highly ornamental. In order to insure these being properly constructed, and to show how they may be made rather ornamental than cumbersome, we will describe a little more fully the minutiæ of their construction. For the fresh-air pedestal, make first an opening of sufficient size in the deck, in the position where it will be most out of the way; construct an ornamental pedestal, (or a copper tube may be more easily and cheaply erected,) with the inside diameter equal to that of the aperture. The pedestal should be hollow throughout its whole length. At the top, have one side of the cornice left open, communicating with the inside diameter: to facilitate the passage of the air, the edges of this opening, both out and inside, should be neatly rounded. Of course, the *top* of the pedestal must be closed. The cornice (even of a *square* pedestal) should be made to turn easily round in any direction, so as to make the hole opposite to the quarter from where the wind may blow. It is evident that, in calm weather, the foul air will be withdrawn through this; and in order, at such times, to take full advantage of its withdrawing powers, the cornice may be made so as to lift off altogether, or the top may be hinged at one side. But in stormy weather there will be, with this contrivance, a means of supplying fresh air to the interior: this is of very considerable importance, as the doors and other apertures will be closed on such occasions. From the aperture in the ceiling of the cabin, communicating with the interior of the pedestal, lead a leather or gutta-percha tube down to the floor of the cabin; turn the aperture of the cornice to the wind. In a hard gale, it is evident that a *very* powerful current of air, pure and refreshing, will be forced down the tube and into the interior of the cabin. As in very heavy gales the current thus sent down will be too forcible, a register-plate, with a circular valve, may be put at the lower end of the tube. Now, supposing that a circular aperture be made in the floor of the cabin, directly beneath the opening of the pedestal, (this communicating with tubes or air-channels placed beneath the flooring, and leading to apertures before the front of each berth,) a due supply of pure air would thus be supplied to each inmate, at the time when the want of such would be most severely felt. We are aware that many proprietors of vessels will object to this plan—finding fault, doubtless, with a huge ugly pipe dangling from the ceiling; but we beg to assure them that, in stormy weather, the companion-ways battened down, close, sickening air in the cabins, the advantages of such a plan would be so obvious, and agreeable in its effects, that, instead of objecting to it as an unsightly contrivance, the passengers would hail it as a boon, and be exceedingly thankful for it. But such a pipe might be permanently fixed, and made highly ornamental; and surely if a stove-pipe, for leading the smoke from the cabin stove, is tolerated, no objection can be made to a similar contrivance, having for its object such an important purpose as the supply of air. If the pipe is made permanent, the opening of the pedestal cannot be made use of as a foul-air ventiduct. Fortunately, almost every ship has a central skylight in the ceiling of the cabin, thus affording the best possible place for an opening to be made for withdrawing the foul air. Some skylights are made flat in their upper parts; they should, however, be invariably made sloping, gradually lessening from the main aperture to a square place in the centre, say some 12 or 14 inches in size. This square place should never be movable, but the parts between the astragals supporting it may be hinged, so as to be opened in fine weather. In the centre of this square piece cut a hole of sufficient size, and over it fasten, in the outside, a short pedestal or ornamental top, some 8 or 12 inches high, and so constructed (according to some of the plans we have shown) to allow of the egress of the foul air, while preventing the ingress of the fresh. Guager's chimney-top, described in Chapter V., may be masked by an ornamental outside cover, and it will prove, at the same time, ornamental and useful. If this contrivance is adopted, care must be taken to have the parts of the sides opposite to the open apertures at the bottom of the "top" left open, and the top of the covering, if any, perforated with small holes—or a plate of perforated zinc may be used for such.

The galley fire on board some ships has been used to sustain a ventilating power. "Nothing," says Dr Reid, "however, more certainly tends to improve the atmosphere of a ship, than the influence of a galley fire, as it may be made to serve the same purpose as a shaft; but the objections to sustaining the fire at night, and the size of the communications required for effective ventilation, must prevent its being so extensively useful for such purposes as might be imagined. By establishing a communication between it and the hold, or any part of the ship where ventilation may be more urgently required, a certain benefit may be always secured, which will be productive of much good, even where nothing else is attempted." With these remarks we perfectly agree: from the local peculiarities, however, of the galleys on board ship, it is almost impossible to have channels sufficiently air-tight leading from the places to be ventilated to the fireplace, through which the latter is supplied with the air necessary for combustion. But there is no difficulty in making channels of some effective size, by which, though even in a small measure, the ascending current of foul air from the cabins may be kept up. Thus, from the ceiling of the main cabin a pipe might lead along and under the deck to the ash-pit of the fire; so long as the fire was maintained, a current of foul air would be withdrawn from the tube, and through it from the cabin. If the power of the galley fire should not be used for this purpose, it ought certainly to be put in operation to draw the air from the water-closets, if these are placed between decks. The importance of this need not here be dwelt upon. In supplying the hold, between-decks, or cabins with fresh air, Dr Arnott's ventilating pump may be used with considerable success. In cases where apertures for taking advantage of the natural currents cannot be made, this machine or other similar effective apparatus, as fanners and screw ventilators, should invariably be supplied to every ship leaving port for long voyages. The power of a boy or man, working for a short space several times a-day, would force in sufficient fresh air (care being taken to have apertures left for the escape of the vitiated) to keep the between-decks and cabins comparatively fresh and sweet. To make such machines completely effective, the air from them should be led to the floor of the cabins by flexible pipes: gutta percha would be found most eligible.

There is no class of ships in which ventilating apparatus is more required than Transatlantic emigrant vessels. In order to give the reader some idea of the state of matters on board these vessels, we cannot do better than give the following remarks extracted from an Emigrant's Guide to the United States, recently published, entitled *Who should, and Who should not Emigrate*:—"Here a few remarks on the state of emigrant ships may be allowed, as in some measure they may call the attention of humane parties to their condition. Much has been written and said by philanthropic individuals concerning the sanitary condition, as it is termed, of the houses of the labouring classes on shore, and much has been done, and is now doing, for their improvement; but yet the *horrid* and disgraceful condition (I use the terms guardedly, convinced of their truth) of the between-decks of the great majority of the emigrant ships has never yet been thought worthy of the like consideration. This is from no apathy, we feel convinced, on the part of such noble men, but solely, I take it, from ignorance of the facts; yet I can assure them that there is, in connexion with the condition of emigrant ships, a wide field for the exercise of their benevolent views and humane and Christian efforts. To designate them in some cases as 'floating plague or pest houses,' would not be using too strong language. I could here give extracts from different New York papers, which would be strikingly suggestive of the horrors of these places. Announcements may, every day almost, be read of an emigrant ship arriving in that port having had thirty and twenty deaths from cholera and ship fever. I trust that more frequent attention will be drawn to this point, important in its bearings upon society—that our philanthropists will forward, by their influence and exertions, all plans put forth for the improvement of the means of emigrant transportation—to place it on a footing more consistent with the principles of humanity, not to mention the higher ground of Christian privilege and duty. If it is true that a good supply of light and air is necessary on shore, it is no less true, that such is equally requisite at sea. Suppose to yourself a long, narrow, low-roofed apartment, lighted so sparingly—by means of a square hole or two in the deck, and small, very small holes, filled with thick glass, in the stern windows—that to read small print at a short distance from these parts is a matter of great difficulty, and in the majority of places so as to render it almost impossible to distinguish the features of the person you may be speaking to, or the neighbour who may be lying by your side. Then in the time of storm and tempest, the hatches fastened down and the stern lights closed, no light but what is afforded by the ship lamps hung at each end of the long apartment, shedding a dreary light around, and consuming more than its light is worth. Add to this, disease and death prevalent around, and you have an idea, a faint idea, of the between-decks of an emigrant ship in all cases. Some ships are supplied with one or two ventilators, for the purpose of withdrawing the foul air; these are altogether too small to be of much use.

But no provision, that I have yet seen or heard of, is made for '*supplying the interior of emigrant ships with fresh air.*' The only means of doing so is by the hatches and the stern lights. These latter supply a good deal ; but even a moderate sea running causes them to be shut. In every gale the hatches are also closed, so that little air is supplied to the interior In reading a review of a new work in *Blackwood's Magazine*, I find the following, which I transcribe for the benefit of my readers, and as corroborative of what I have said on this point. Pray take notice of the words in *italics*, they convey a great deal in a small space. "Part of the Highlander's cargo was five hundred emigrants, to accommodate whom the between-decks were fitted up with bunks rapidly constructed of coarse deal, and having something of the appearance of *dog kennels*." Graphic indeed is the picture of the steerage when the malignant epidemic breaks out, and it becomes a *lazar-house, frightful with filth and fever ;* until at last favourable breezes came and fair mild days, and fever fled, and the *human stable* (*for it was no better*) was cleansed, and the Highlander bowled cheerily onwards, over a pleasant sea, towards the much-desired haven."

After this long extract, our readers will in some measure be prepared for the announcement made by a New York paper, that, out of "one hundred and ninety thousand arriving here during the year 1848-9, and others at American and Canadian ports, we have reliable data for asserting that over *twenty-five thousand have died*—war has never proved so frightful a destroyer of human life as emigration." Now, this appalling state of matters is certainly caused by the defective ventilation of the vessels used for transporting emigrants. Doubtless other causes exist, as want of nourishing food and sufficient clothing ; but we venture to assert that the mortality thus shown to exist to a frightful extent would be greatly mitigated, were all emigrant ships properly ventilated. We are certainly of opinion that the legislature ought to make it compulsory on all shipowners to ventilate their vessels effectually. Portable ventilating apparatus should be provided in every case—plenty of hands would be found to work these efficiently and cheerfully. And in connexion with these might be used simple "medicating apparatus," which would be useful in throwing into the space between-decks, medicated air, or *fumigating vapours*. And for cases of fever, hospitals should be erected on deck, taking care that they are well supplied with ventilating apertures. The medicator, according to the plans made by Dr Reid, for the use of the Niger steamships, may be briefly described as a box, at the end of which the air entered from the windsail, passing through a strainer to arrest any impurities. It next was passed over certain chemicals placed in the bottom of the box, and on shelves, over which it passed, and was finally projected into the place required. A very efficient ventilator-medicator may be made out of a square deal box, having a pipe attached at one end leading to the windsail, or pump fanners, &c., and at the other a similar pipe, leading to the interior of the cabin. By placing a flat dish with chemicals, or with substances emitting fumigating vapours in the inside of the box, between the two pipes, air will be forced into the interior charged with the required vapour.

We have only referred to the supplying of the cabins where passengers are in the habit of remaining; but care should be taken, in all cases, to supply those invaluable persons on board ship, the sailors, with a proper quantity of fresh air. "In a few minutes," says Dr Reid, "in general, after the men retire to rest, the atmosphere around them becomes saturated with moisture, and largely charged with carbonic acid and animal exhalations. Even then, it is almost insupportably offensive to the majority of individuals accustomed to a better atmosphere, who place their head for a short time between the hammocks. It is perhaps not too much to affirm, that the premature old age which appears to creep upon the sailor, who sleeps where such an atmosphere prevails, arises more from this cause than all the other hardships to which he is exposed—particularly when it is recollected that his natural sleep is broken by unequal watches, and that he is not unfrequently called upon to pass from this enervating and over-heated atmosphere, to encounter all the severities of the storm and the coldness of the midnight air." The importance, then, of ventilating the sleeping apartments of the seamen, will, we trust, be acknowledged by the proprietors of vessels, and that means will henceforth be taken to insure an equal supply to them, acting efficiently in all cases.

In ventilating steamboats, the engine-room could be supplied with fresh air in calm weather by the action of one paddle, while the other would be operating in the withdrawal of the foul. To understand how the paddles can be made thus effectual, it is necessary to explain that all paddles move the air surrounding them, as well as the water with which they come in contact; in fact, they are in a certain degree fanners on a large scale, possessing the property of drawing in air from the centre, and discharging it from the circumference. Now, by making apertures in the boarding of the engine-room, forming one side of the space in which the paddle works, near the centre, that air will be withdrawn through these, and discharged at the circumference; but, as water might be dashed through the apertures, a cover might be placed on the boarding opposite them, having a pipe leading from its upper side to the ceiling of the engine-room. Fresh air can be obtained by the other paddle, the openings being made for its admission on the outside of the paddle box—but we would recommend fresh air to be supplied by ventiducts leading from the deck. The supply of air to the furnaces of steamboats, generally, is very badly managed. "At present, the cold air too often descends abruptly in front of the fire; the firemen are subjected to a precipitation of cold air upon their heads, when perspiring profusely; *and, the fires being supplied with sufficient air by the openings near them, those at a distance do not admit air, but often discharge vitiated air, to the annoyance of the passengers.*" "Cases have occurred," says Dr Reid, from whose work the above extract has been taken, "where a steamship of acknowledged slow speed, has, after a new and skilful disposition of the channels for ingress of fresh air, proved superior to another that always sailed faster previously. In one of these, the alteration was made so that the air entered by the bows and pressed upon the fires. Hence, in calm weather, the faster the ship went the greater the force of the current, entering as from a bellows, and sustaining the fires with more power than they otherwise would acquire."

In withdrawing the foul air from the engine-room by means of the paddles, an independent supply of pure air should be provided for the furnaces, as the action of the paddles is so violent that they would rapidly draw the supply even from the fireplaces; hence, likewise, the importance of supplying the engine-room with an adequate quantity of fresh air.

The foul air might also be extracted from the engine-room and some adjacent apartments, as the water-closets, by leading pipes to the under part of the main funnel, or to the fireplace of the galley. In all such places, it will be necessary carefully to guard against fire: this will be prevented by putting before the mouth of the pipe, as it enters the chimney or fireplace, several folds of wire gauze.

By supplying the furnaces, or one furnace, (for there are generally more than one in every steamboat) with air drawn exclusively from the various cabins, the foul air from these would be effectually withdrawn; but, "this is not considered in all cases so desirable a mode of proceeding as might be anticipated, as the free and unfettered supply of air to the fires is sometimes of great importance in sustaining the speed of the engine." Moreover, from the frequency of the operations requisite to keep the fuel in the best possible condition for active combustion, it is exceedingly difficult to have the air-channels fitting tightly at the furnace mouth. In all cases, then, where apertures cannot be made to carry on ventilation by means of natural currents, the best mode is to use the power of the engine to work properly constructed fanners or pumps. It may be objected to this, that the power used for such will retard, very considerably, the speed of the engine; but surely, if ventilation is of any importance at all, it is the duty of every proprietor of a steam-vessel to provide extra power for working ventilating apparatus; and we are somewhat inclined to think, that it should be compulsory on the part of every proprietor to provide such. But, in cases where no extra power has been provided, the working of efficient apparatus would make no observable difference in the rate of speed—that is to say, if they were worked judiciously. For it should be observed that small fanners, for instance, if wrought at a high speed—say six hundred to one thousand revolutions per minute—take greater power to work them than when large, and having a low rate of speed—in fact, the resistance increases in proportion to the velocity. Again, it should be remembered that the velocity with which air is sent into the interior of an apartment is not the material point to be obtained, but the quantity: thus, it is better to have large fanners working at a slow speed, than small ones working at a high speed—

not only on account of the saving of working power, but for obtaining the highest rate of efficiency.

Of ventilating machinery, the fanners we recommend as the most eligible; the "rotatory motion by which they are worked, and the continuity of the stream which they produce, affording great advantages for ordinary purposes." They are made in various ways—some with flat, and others with curved blades; some drawing in air throughout their whole extent; others, through apertures made near the centre, in the sides enclosing the blades: but in all cases the action is the same—drawing in air at the centres and discharging it at the circumferences. Ventilators have been constructed on the principle of the Archimedean screw, and are, when properly made, capable of giving great satisfaction, either for extracting or supplying air. Mr Combe of Leeds introduced a double-threaded screw, as a ventilating instrument, in the extensive establishment of the Messrs Marshall of Leeds, "working it with a six-horse steam-engine, and obtaining very satisfactory results." Dr Reid recommends this as the most efficient of the screw ventilators.

The fanners used in steamboats should be placed in the engine-room, but have no connexion with the atmosphere therein; the air to be supplied, being drawn from the external atmosphere through a pipe leading to the two openings made in the sides of the fanner, and pipes leading from a place at the circumference to the floors of the various apartments to be supplied with air. If the air is thus led to the floors, the vitiated air should be allowed to escape by the skylight of the main cabin, the sleeping apartments having connexion with it by apertures made in the upper part of the walls or partitions. The fanner may be used also for extracting the foul air, by having tubes connected with the openings on the sides, leading from the ceilings of the various apartments, and the air propelled from its circumference up a tube leading to the external atmosphere.

In concluding our remarks on this part of the subject, we would remind our readers that, to insure efficient ventilation on board ships—sailing or steam—proper apertures for the ingress of fresh, as well as for the egress of the foul, are essential. If natural currents are depended upon, carried into effect by any of the ways we have described, these apertures should be independent of one another; that is, one aperture should be used for the withdrawal of the foul, and the other for the admission of the fresh—placing dependence by no means upon one only, to be used for both purposes. We have already stated that the fresh air pedestal, when without a pipe in the interior, would act in calm weather as a foul air ventiduct; but we only meant to convey the idea that it might be used in conjunction with the regular foul air ventiduct, on such occasions the fresh air being introduced by the doors. If "fanners" are used, either for propelling fresh air into, or withdrawing foul air from, the interiors of the cabins, care should be taken to make the tubes for such large enough, and by no means to have the bendings made at right angles. Easy curves should always be adopted, and every means taken to have the inside smooth, so as to lessen as much as possible the friction of the passing currents, which will be found to be very considerable.

The ventilation of railway coaches and private carriages is of considerable importance. In some railways, where the third, and in some instances the second, class carriages are formed in one large apartment, (without any partitions dividing it into separate compartments,) the atmosphere sustained in the interiors, when the number of passengers is great and the windows are closed, is absolutely suffocating. Again, when the windows are opened, the air rushes in with violence, and in such undiffused volumes, as to render in winter the cold almost unbearable. In first-class carriages, from the close nature of the fittings, when the windows are closed, the state of matters are even worse than in the second and third class ; and when the windows are opened, the undiffused air is precipitated on the heads and faces of the occupants.

In ventilating carriages, they should all be divided into compartments like the first class : this renders the amount of contaminated air in any one space less in volume, besides possessing many other advantages. The air should be supplied by an air-tight channel, running along the bottom of the carriage, and communicating at either end with the atmosphere through apertures covered with very finely perforated zinc. The channels for admitting fresh air to the compartments should be placed beneath the seats, opening outwards to the interior through plates of finely perforated zinc placed on the fronts of each : these channels, of course, communicating with the main channel which runs beneath the carriage. The apertures for the admission of the fresh air, at the ends of the carriages, should be placed under efficient control by means of valves. The means for withdrawing the foul air will be easily obtained, by having an aperture at the ceiling, in the centre of each compartment, provided with a properly constructed top on the outside of the roof : this may be made in the way of Guager's top, and masked, if necessary, by a cylinder punched with holes. If the top is made in the form of a pedestal, capable of revolving on its base with one side open, it is evident that, when turned from the wind, the force of the current passing it will withdraw the foul air from the interior very speedily. If, on the contrary, the opening is turned towards the wind, the air will be forced into the interior with considerable velocity, the rate of which will be in a corresponding ratio to that of the engine pulling the train. Thus, after a compartment previously very full has been *vacated*, the guard, by turning the aperture to the wind, may send in a large supply of fresh air, to sweeten the interior for the next comers; and, on their taking their seats, he will merely have to turn the aperture of the ventilator from the wind, when it will resume its action as a foul air ventiduct—the fresh air being supplied by the channels previously described. In the evening, when the interior compartments are lit up by the lamps, if these are inserted in the ventilating apertures in the ceiling, it is obvious that the effect will be effectually to stop all egress through these, so long as the lamps are allowed to remain. Hence will be seen the absurdity of thus closing up the only apertures made in railway carriages at present for the withdrawal of foul air; and yet this is done in every railway in the kingdom. Now it seems, by the manufacturers of railway-carriage lamps, to have been completely forgot, (if at all known,) that the very nature of the process of combustion kept up in them provides an admirable plan of withdrawing the foul air from the interior of carriages in which they are placed. Wherever heated air is, there is always an upward ascent of more or less velocity. We have already dwelt on this, so we need not do more than merely draw attention again to it. Our readers are aware of the globular form of the railway-carriage lamps: supposing apertures were made in the glass, at short intervals round its circumference, within half-an-inch of the roof, the air from the interior would rush through these to join the upward current in the lamp. Again, supposing the lamp to be fed by air, from the carriage by an aperture in the bottom of the globe, an upward current would be maintained, drawing the air from the carriage. As, however, either from the carelessness of the attendants in filling the lamps, or from some defect in their construction, the camphine or oil used for lighting them is frequently found lying in the bottom part of the globe, the first plan we have described will be the better one, though scarcely so effectual. If the lamps could be made perfectly tight, the best mode, assuredly, would be to supply the air necessary for combustion from the interior of the carriage, taking care to draw it from the greatest possible elevation. Another plan for taking advantage of the upward current of the heated air of the lamp may be adopted, where objection is made to having the air of the carriage mix in any proportion with that of the interior of the lamp. Let the upper part of the lamp consist of a cylinder of very thin metal, say brass ; surround this with another cylinder, of larger diameter, so as to leave a space of half-an-inch or so all round, between them ; let both these cylinders be of the same height, and both opening at the top to the external atmosphere—the heated internal cylinder will cause an upward current, in the space between the two tubes ; and if the opening of such space commence within half-an-inch say of the roof, it is evident that the air from the compartment will be withdrawn through it. We throw out these hints without further elucidation ; the principle is so obvious that no practical man will have any difficulty in carrying out efficient plans to take advantage of it. The fresh air supplied to the interior of all carriages should be extremely well diffused : to insure this, very finely perforated zinc should alone be used—the finer the holes the better. To prevent the precipitation of large volumes of air, wire gauze blinds should be provided to each carriage, which should be easily drawn up or let down when required. We are happy to find that some railway companies have already adopted them. When the windows are opened, these may be drawn up, and, if not too fine in the meshes, will not obstruct the view very materially. The colour they are generally made—namely, *green*—is the best that can be adopted, as it does not hurt the eyes. A light blue would also be pleasant.

The heating of railway carriages is by no means to be considered as an imaginary proposal—we here give Dr Reid's: "It would also require very little ingenuity to construct the floor of iron, so that in severe weather it might be made to offer a gentle warmth, sufficient to take away all sensation of cold. Small loaves of prepared charcoal, requiring merely to be kindled at one end, or a small lamp might be used, where combustion is sustained by air entering and discharged altogether without the coach, *and having no communication whatsoever with the interior.* The supply of air would regulate the combustion." To carry this plan into effect would require other arrangements besides those for the mere ventilation; we therefore propose to combine the heating and ventilation in one. To insure a source of heat, we know of no contrivance more easily attainable than a receptacle containing hot water. With a copper dish or flat bottle, some two feet square and four inches thick, filled with hot water on starting, we have known a mild and agreeable heat maintained in the cabin of a canal packet for four hours. We would then, for heating the air supplied to railway carriages, recommend a modification of this simple contrivance to be adopted. A flat box such as we have described, placed at the aperture at the ends of the carriage for admitting fresh air, would heat the air passing over it. It is evident however, that, the greater the surface exposed, the greater the effect that will be obtained. A flat box would at least have one side non-effectual in giving heat, namely, that on which it rested. Some heat would be given, doubtless, to the floor on which it lay; but the desideratum is, to have as much surface exposed as possible to the passing current of fresh air. Supposing the height of the fresh-air aperture to be 10 inches—the extreme depth of the box, to pass easily out and in, would be 9 inches—make the breadth two feet or eighteen inches, and so contrive slits or apertures to pass through the interior, affording a variety of passages for the air to go right through it. These slits may be quarter of an inch or three-eighths of an inch wide, eight and a half inches deep, and of course the width of the box—they should be made perfectly water-tight. The whole apparatus should lie on one of the broad sides, and be lifted off the floor by feet, placed one at each corner, and one in the centre. The aperture for admitting the *boiling* water should be on the top side, and secured by an air-tight screw. For withdrawing the water when cold, the under side should be provided with a stop-crane: it will be necessary, when this is opened, to have the top screw also taken off, to admit of the pressure of the air on the upper side. If such an apparatus is used, it is clear that a much larger current of heating surface will be obtained than when no apertures are provided running through the box, as we have described. The surface of the outer portion will have the important addition of that of the insides of the long and deep apertures—these, being surrounded by the water, will give out heat in a corresponding degree to that of the outer ends and sides. In fact, the area of the sides of each aperture will very nearly equal that of both the outside ends. Supposing the box to be 2 feet square in size, and 9 inches deep, there would be more than 30 square feet of heating surface; of which nearly 20 would be obtained from the apertures or slits passing through the box. One box would give heat to two compartments at the very least; but if a box was supplied at each end, the allowance would be amply sufficient. Some such contrivance could be easily adopted in the severe winter months, and with very obvious advantages, fresh supplies of hot water being obtained at certain stations.

In supplying air to carriages, more particularly the second and third classes, we cannot too strongly deprecate the plan of admitting cold air by louvres placed at the sides. These throw the air, in very perceptible currents, chiefly about the head and neck; air should always be *supplied* beneath the zone of respiration—never above.

The plans we have now described, may be carried out with striking advantage, in every species of carriage—stages, omnibusses, and private conveyances.

In the latter, simple plans for securing the withdrawal of the foul, and an ample supply of fresh air, are much desiderated. The fresh air should be supplied by apertures at the bottom of the *front* of the carriage, diffusing it as much as possible by fine wire-work or perforated zinc. The foul may be withdrawn by an aperture in the top, covered on the outside with a neat "top," decorated and painted according to the style of the carriage. In cold weather, some simple heating apparatus may be placed before the apertures in the front; or a box made of strong but thin metal, filled with hot water, may be used to rest the feet upon. This latter contrivance might be used in railway carriages, in cases where the more complex plan we have described is objected to.

In conclusion, we would beg leave to throw out a few hints relative to the practice of taking what is called a "carriage airing." Amongst the many absurd methods we see daily around us, taken to *secure*, as it were, a good supply of atmospheric poison to our lungs, we are inclined to give the practice of modern "carriage airing" the palm of high supremacy. "Gravely ludicrous," as is the practice, it is equally inducive of a large amount of personal suffering. A party at home is troubled with headache; a carriage airing is proposed and agreed to; the carriage is entered, the doors closed, the windows immediately drawn up. All is close, tight, and—*comfortable?*

The horses prance gaily onwards, inspirited by the fresh breezes playing around them. Of course, the inmates feel some of this? — No. In a short time the faces become flushed; the headaches worse; the breathing is difficult; the heated air is condensed on the glass, and trickles slowly down. The drive continues; the contaminated air is breathed again and again; and at last they arrive at home, depressed in spirits and pained in body, and exhaust themselves in their expressions of wonder, that the airing so highly recommended has not been beneficial to them—forgetting or being ignorant of the fact, that a "fresh," not a "foul" airing was extolled as being good. How often are convalescent invalids taken out from a *comparatively* pure atmosphere, and mewed up in a close carriage, the effects of which must considerably retard their recovery. In some instances the effects are not so observable; in others, however, they are immediate, the parties fainting away, but brought to consciousness by the opening of the doors or windows, in the eagerness of their attendants to obtain assistance. We trust that the members of the medical profession will consider these remarks worthy of attention : many of them are fully aware of the absurdity and danger of the practice, and take every opportunity to expose it. But, so far as our experience goes, that degree of care has never yet been given by the profession, as a body, to the regulation of the *outdoor* exercise of their patients, which the importance of the subject certainly demands.

THE END.

PRINTED BY WILLIAM BLACKWOOD AND SONS, EDINBURGH.

ADVERTISEMENT

THE Author of the present Treatise begs to acquaint Noblemen, Gentlemen, Agriculturists, Committees of Public Buildings, and Steamboat Owners, that he is ready to prepare detailed PLANS and SPECIFICATIONS for VENTILATING and HEATING, on the principles elucidated in the foregoing pages.

ELEGANT DESIGNS for Ventilating Arrangements, and HEATING APPARATUS for Public Buildings and Private Residences, prepared with all expedition and accuracy.

He would impress on the notice of Parties about to Build, that Plans can be incorporated with the *original designs*, and carried into execution, at a comparatively trifling outlay. PLANS and SPECIFICATIONS of Agricultural Edifices and Commercial Warehouses also prepared. In the latter, Plans will be proposed for the Prevention of Fires, and the speedy extinguishment of such as *may* break out; the principal feature in these being the Isolation of the various Apartments one from another, yet so arranged as not to interfere with the business details—preventing the recurrence of all such catastrophes as have recently happened in the burning of Warehouses.

Letters (paid) addressed to the Author, care of the Messrs Blackwood, Edinburgh, or 37 Paternoster Row, London, will meet with immediate attention.

N.B.—Inventors of Ventilating or Heating Contrivances or Designs, dependent upon the principles elucidated in this Work, may have them reviewed by sending the Plans, &c. to the Author, as above directed.

CATALOGUE OF BOOKS

PUBLISHED BY

WILLIAM BLACKWOOD & SONS

45 GEORGE STREET, EDINBURGH.
37 PATERNOSTER ROW, LONDON.

ALISON'S HISTORY OF EUROPE.

Extracts from Notices of the Library Edition.

"Two or three obvious facts are, no doubt, closely connected with the remarkable success of the 'History of Europe.' It is the only substantial work that we have with reference to *all* the period and *all* the important events of which it treats; it deals with a section of history in which every living man is almost personally interested; it grapples with questions whose solution has yet to be recorded; and it comes before a generation astounded by the din and confusion of a dozen political and social revolutions, explaining the causes and defining the mixed results of one fearful revolution which, in some respects, may be regarded as the father of them all. . . . We can honestly recommend the present edition, in all respects, if such recommendation be needed at all by a publication which contrives to take such admirable care of itself."—*The Times.*

"In common with all, we are deeply indebted to its learned, acute, and eloquent author for this monument of British wisdom, British honour, and British prowess; but, as journalists, we are especially bound to acknowledge that often Mr Alison has furnished us with facts and arguments, and the exposition of great principles, by which we have been enabled to combat the falsehoods and sophistries of the ignorant or malicious enemies of that system by which Great Britain obtained strength to restore peace and liberty to the world, and to become, in the most glorious sense, the queen and benefactress of nations. History has been described as 'philosophy teaching by example,' and never did any historical work fulfil the conditions of this description better than the work before us. . . . . This task Mr Alison has accomplished in a work—simple, graceful, and forcible in its style, eminently clear in its arrangement, but, above all, characterised by a most chaste impartiality, and by the unquestionable good faith which is ever sure to win the confidence and secure the attention of an honest and intelligent reader."—*The Standard.*

"Our criticism must now be confined to a few words concerning the most novel feature of this re-issue, namely, the portraits. The illustration of a work of high reputation and importance is a task demanding great care and judgment. If not of authentic resemblance and first-rate execution, portraits degrade rather than adorn a grave historical work. In this instance the utmost pains have been taken to make the pictorial embellishments correspond in excellence with the text they illustrate. . . . . Continued as it has begun, this series of portraits will be, when complete, without a parallel for combined interest of subject and excellence of execution."—*The John Bull.*

"The *eighth* edition published of this extraordinary work—a work not less remarkable for its laborious research than for the lucidity of its style and the eloquence of its composition. . . . We have here submitted to our consideration the first volume of an edition superbly embellished—printed in octavo with new pica type—and accompanied with a re-issue of the costly atlas produced by the distinguished geographer, Alexander Keith Johnston."—*The Sun.*

Catalogue.

LIBRARY EDITION OF ALISON'S EUROPE.

Publishing in Monthly Volumes, Price 15s. each,

A New Edition, in Octavo, of

THE HISTORY OF EUROPE.

BY ARCHIBALD ALISON, L.L.D., F.R.S.E.

This Edition is printed in Demy Octavo, with a new and elegant Pica Type, on Superfine Paper, to range in Libraries with the Standard Editions of our English Historians; and is

EMBELLISHED WITH PORTRAITS.

One Hundred Copies have been printed in Royal Octavo, with Proof Impressions of the Portraits; uniform with which an Edition of the ATLAS is issued.

To be completed in 14 Volumes.

ALISON'S HISTORY OF EUROPE.

Lately published,

THE HISTORY OF EUROPE.

BY ARCHIBALD ALISON, L.L.D., F.R.S.E.

A NEW EDITION, BEING THE SEVENTH.

In Twenty Volumes, Crown Octavo, with a Copious Index.
Price £6, bound in Cloth.

All the Volumes are now reprinted, and may be had separately.

Notices of this Edition.

"At the time this great work appeared in successive volumes, we noticed lt at such length, that any detailed repetition of its merits would be superfluous. In spite of the defects which may appear in isolated parts—and how could a work of such magnitude be without them?—it is unrivalled as a *Thesaurus* of information, during one of the most important periods of the world's history; and is at the same time a monument of Industry and eloquence. Having passed through six editions in its original octavo form, a seventh has now commenced in a more portable shape. The size adapts it to the pocket, while the beauty of the appearance qualifies it for a place in the library of the most fastidious."—*Times.*

"So fully are the abilities of our historian appreciated, that we shall content ourselves with simply commenting upon the peculiarities which exclusively characterise the present edition. In its publication the utmost care has been taken to preserve every portion of the original unmutilated and unabbreviated, so that in the compass of a most portable volume, are comprised the entire contents of an octavo or even of a quarto. The classification, the arrangement of the chapters, the foot-notes, and the marginal references, are singular for their compactness; and this supervision has even extended to the enumeration of the authorities quoted in the narrative. A merely superficial glance at this catalogue will be sufficient to show the enormous research and labour required in the composition. Even in external appearance, the work is remarkable for the attention paid to its general character, the binding being at once chaste and substantial. . . . . A better edition, suited to the public at large, could not possibly have been issued."—*Sun.*

"His pages embody some of the most valuable lessons of Christian philosophy, and the loftiest precepts of public morality. They have already received the seal of general approbation; and we cannot doubt that the favour extended to them in the elegant and moderately priced form in which they now appear, will be still greater and more lasting."—*Morning Chronicle.*

"After standing the test of time and criticism, in continuous publication, volume by volume, both in England and America, and reaching a sale equivalent to six editions, the seventh edition of 'Alison's History of Europe' is now to appear in a more compact form, at a lower price, and in a closer, and, we think, a handsomer style, both as regards type and paper."—*Spectator.*

THE ATLAS

TO

ALISON'S HISTORY OF EUROPE.

CONSTRUCTED AND ARRANGED, UNDER THE DIRECTION OF

MR ALISON,

BY

ALEX. KEITH JOHNSTON, F.R.G.S., F.G.S.

In Crown Quarto, uniform with the Seventh Edition of the History, price £2, 12s. 6d., bound in cloth;

In Demy Quarto, to range with the early Editions, in Demy Octavo, price £3, 13s. 6d., bound in cloth;

A Re-issue, chronologically arranged, publishing in Monthly Parts with the Library Edition of the History, Demy Quarto, price 3s. 6d. each.

The same in Royal Quarto, to accompany the Royal Octavo, Library Edition, price 4s. 6d. each.

CONTENTS.

[*Continued.*

Atlas to Alison's History of Europe.

CONTENTS—*continued.*

MEMOIRS AND ADVENTURES

OF

SIR WILLIAM KIRKALDY OF GRANGE,

Knight Commander of French Horse, Lord of the Secret Council, and Governor of the Castle of Edinburgh for Mary Queen of Scots.

In One Volume, post 8vo, price 10s. 6d.

"It is seldom indeed that we find history so written,—in a style at once vigorous, perspicuous, and picturesque. The author's heart is thoroughly with his subject; and he exhibits, ever and anon, flashes of the old Scottish spirit, which we are glad to believe has not decayed from the land."—*Blackwood's Magazine.*

"In truth, we do not know when we have studied a biography so pleasantly and graphically written as the work before us. It is the very spirit of Sir Walter Scott transfused into history; and it is so because the author appears to have passed over every spot of ground which is referred to in his book—to have studied the position of the parties whose deeds are depicted by him, and thus to have lived again amongst the men of whom he gives an account."—*Morning Herald.*

"One of the most remarkable and valuable contributions to Scottish History that the fertile press of our northern neighbours has ever given to the world,—a history which embraces within its range many of the most memorable incidents in the life of Mary Queen of Scots—which brings us often into the company of the veteran reformer John Knox—which records the violent deaths of no less than four successive representatives of royalty, and which pictures Edinburgh with her famous castle garrisoned and fortified, and the cannon on its battlements sweeping the city below them. A history like this must take a prominent and permanent place in Scottish literature."—*Dorchester Journal.*

THE MAXIMS OF SIR MORGAN ODOHERTY.

In square 16mo, gilt edges, price 2s.

Uniform with BURTON'S LIFE OF HUME,

LETTERS OF EMINENT PERSONS,

ADDRESSED TO

DAVID HUME, ESQ.

Containing original Letters from Horace Walpole—Helvetius—Bishop Douglas—Lord Lyttleton—Mirabeau the elder—Lady Hervey—Col. Barre—Sir Jas. Macdonald—The Earl Marischal—Strahan the Printer—Lord Loughborough—Lord Hardwick the younger—Lord Hertford—Marischal Conway—Mrs Cockburn—Turgot—D'Alembert—Mlle. de l'Espinasse — Coutts the banker — Edward Murphy—Dean Tucker—Sir Jas. Stewart—Malesherbes—Mad. de Boufflers—Holbach—Sir John Pringle—President de Brosses—Diderot—Buffon—Mad. Geoffrin—Prevost—La Condamine—Crebillon, &c.

In 8vo, price 10s. 6d.

"It is altogether one of the most valuable and instructive collections of letters which has seen the light for many years—abounding in points of great and varied interest for the general reader, while it furnishes a rich store of materials for the more recondite purposes of the student of literary, social, and political history."—*Glasgow Constitutional.*

THE WAR IN INDIA.

LEAVES FROM THE JOURNAL OF A SUBALTERN,

DURING THE CAMPAIGN IN THE PUNJAUB, 1848-49.

In One Volume, small 8vo, price 6s.

"An extremely graphic, animated narrative of events, most readable from the first page to the last, does much more to convey to the reader's mind a just and vivid conception of the lights and shadows of life in an Indian camp—the suspense before the coming strife, the wild excitement of the affray, and the painful reaction of the inactivity which succeeds."—*Atlas.*

"Remarkable for distinctness and descriptive spirit. They give a most favourable impression of the gallantry of our British regiments."—*Britannia.*

PICTURES FROM REVOLUTIONARY PARIS.

SKETCHED DURING THE FIRST PHASIS OF THE REVOLUTION OF 1848.

BY J. PALGRAVE SIMPSON, ESQ. M.A.
Author of the "Letters from the Danube," "Gisella," &c.

In Two Volumes, small 8vo, price 16s.

"The author is not satisfied with merely stringing facts together, he enters deeply into the causes which have produced such astounding events; he traces the bitter fruits of the revolution home to the evil root which bore so corrupt a tree; and at the same time he delineates particular incidents and transactions with great power, and in a style which brings out the salient points of the picture in striking relief, at once attesting the fact that the writer was an eye-witness of the scenes he describes." —*John Bull.*

HUDSON'S BAY;

OR, EVERY-DAY LIFE SCENES IN THE WILDS OF NORTH AMERICA.

BY ROBERT M. BALLANTYNE.

In crown 8vo, price 9s. With numerous Illustrations.

"Its charm lies in the free scope which the writer has given to his feelings, and the perfect simplicity with which he sets down all that he saw or thought. Full of youth, and its irrepressible buoyancy of soul, he knows neither restraint nor affectation; and, whatever be the subject, writes with an animation which the reader cannot withstand."—*Glasgow Constitutional.*

In One Volume, Royal Octavo, price One Guinea,

THE POEMS OF FELICIA HEMANS.

WITH

ILLUSTRATIVE NOTES, A SELECTION OF CONTEMPORARY CRITICISMS, AND A PORTRAIT OF THE AUTHOR, ENGRAVED BY FINDEN FROM THE BUST BY FLETCHER.

"Here is a volume in which high poetry and deep passion are united with feminine delicacy and unsullied moral purity. Here is a volume which a father may give to his daughter on her birth-day, or on some day of this gift-giving season, with a feeling not less confiding or holy than that with which he gives his child her night and morning blessing and kiss. The name of Felicia Hemans has become, and is doubtless destined to remain, one of the loved and cherished household-words in connexion with British poetical literature."—*The Watchman.*

"She is ever alive to the dignity of her calling and the purity of her sex. Aware of the difficulties of her art, she aspired towards excellence with untiring perseverance, and improved herself by the study of the best models, well knowing that few things easy of attainment can be worth much. Her taste thus directed her to appropriate and happy subjects; and hence it has been, as with all things of sterling value, that her writings have not been deteriorated by time. Of no one modern writer can it be affirmed with less hesitation, that she has become an English Classic, nor, until human nature becomes very different from what it now is, can we imagine the least probability that the music of her lays will cease to soothe the ear, or the beauty of her sentiment to charm the gentle heart."—*Blackwood's Magazine.*

"The best, the most accurate, and the most splendid edition that has yet been published of our English Sappho."—*Sun.*

MRS HEMANS' "TALES AND HISTORIC SCENES," &c. Foolscap 8vo, price 5s.

MRS HEMANS' "SIEGE OF VALENCIA," "THE SCEPTIC," &c. Foolscap 8vo, price 5s.

MRS HEMANS' "FOREST SANCTUARY," "DE CHATILLON," &c. Foolscap, 8vo, price 5s.

MRS HEMANS "RECORDS OF WOMAN," "VESPERS OF PALERMO," &c. Foolscap 8vo, price 5s.

MRS HEMANS' "SONGS OF THE AFFECTIONS," "NATIONAL LYRICS," &c. Foolscap 8vo, price 5s.

MRS HEMANS' "SONGS AND LYRICS," "SCENES AND HYMNS OF LIFE." Foolscap 8vo, price 5s.

MEMOIR OF MRS HEMANS, by her SISTER. With a Portrait. Foolscap 8vo, price 5s.

A New Edition, being the Third,

WITH THE AUTHOR'S LAST CORRECTIONS AND A PREFACE,

NOW AND THEN.

BY SAMUEL WARREN, ESQ., F.R.S.

Author of "Ten Thousand a-Year," and the "Diary of a Late Physician."

In One Volume Royal Post Octavo, Half-bound Morocco, Price One Guinea.

"Such is the outline of Mr Warren's present work—a vindication, in beautiful prose, of the 'ways of God to man.' A grander moral is not to be found than that which dwells upon the reader's mind when the book is closed; conveyed, too, as it is, in language as masculine and eloquent as any the English tongue can furnish."—*Times.*

"It is sculpture, not painting, that we have here to deal with. The characters are few, the events simple; and both characters and events stand broadly and boldly out, chiselled into big, massive, rigid proportions. It is a book displaying peculiar and remarkable talents. In parts the narration is of breathless interest. There is an utter and blessed absence of conventionalism about the tale; and it is invested with a species of severe epic grandeur which, as it were, overshadows the mind."—*Morning Chronicle.*

By the same Author,

THE DIARY OF A LATE PHYSICIAN.

A New Edition.

Complete in Two Volumes, Price 12s.

"We know of no book in the English language so calculated to rivet the attention, and awaken the purest and deepest sympathies of the heart, as the *Diary of a Late Physician.* The man who has not read these tales has yet to learn a lesson in the mysteries of human nature; and though *Ten Thousand a-Year* may, as a literary composition, claim precedence, we think it lacks something—a very little—of that truthful simplicity, that trusting and religious fervour, that refines every sentiment and hallows every aspiration inspired by the elder work."—*Oxford and Cambridge Review.*

By the same Author,

TEN THOUSAND A-YEAR.

A New Edition.

Three Volumes Foolscap Octavo, Price 18s.

"The characters are excellent, some of them equal to the highest efforts of the highest masters; the insight into motives is searching; the scenes display a power of reproducing on paper what experience has taught; some of the incidents are novel, startling, and of surprising power."—*Times.*

"*Ten Thousand a-Year* is perhaps destined, in British literature, to some such rank as *Don Quixote* holds in that of Spain."—*American Journal.*

THE PLANTATION SCHEME;

OR, THE

WEST OF IRELAND AS A FIELD FOR INVESTMENT.

BY JAMES CAIRD, FARMER, BALDOON,

Author of "High Farming under Liberal Covenants."

In 8vo, with Map, &c., price 6s.

LIFE IN THE "FAR WEST."

BY THE LATE

GEORGE F. RUXTON, ESQ.

Author of "Travels in Mexico."

In One Volume, small 8vo, price 6s.

"One of the most fascinating productions in this class of literature. The intensely graphic force with which the scenes and characters are delineated, and which is the natural result of the author's personal familiarity with the originals of the pictures drawn by his pen, and of his keen powers of observation, transports the reader's mind involuntarily into the *Far West* itself, among the red hunters and warriors, and the American trappers and mountaineers. To read the volume is almost equal to a personal visit to those romantic regions, and their savage and half-savage inhabitants—so vivid is the impression which the perusal of Mr Ruxton's sketches leaves on the imagination."—*John Bull.*

LAYS OF THE DEER-FOREST.

A SELECTION FROM THE ORIGINAL POEMS OF

JOHN SOBIESKI STUART AND CHARLES EDWARD STUART.

With an Essay on Deer-Stalking and Roe-Hunting, Notes of Remarkable Incidents in Forest Sports, Traditions of the Clans, and Notices of Natural History in the Deer-Forests.

In Two Volumes Post Octavo, price 21s.

THE ANGLER'S COMPANION

TO THE RIVERS AND LOCHS OF SCOTLAND.

BY THOMAS TOD STODDART.

In post 8vo, price 10s. 6d.

WITH FISHING MAP OF SCOTLAND.

"Indispensable in all time to come, as the very strength and grace of an Angler's Tackle and Equipment in Scotland, must and will be 'STODDART'S ANGLER'S COMPANION.'"—*Blackwood's Magazine.*

"Without a second's pause of hesitation, we pronounce the book the best extant as an angling guide to the salmon and trout waters of Scotland, and particularly to the famous Tweed and its many tributaries. . . . . . Every angler who has an ambition to become an adept in the art of killing trout and salmon by means of rod and line should peruse assiduously Mr Stoddart's work."—*Bell's Life.*

The Baronial and Ecclesiastical Antiquities of Scotland.

Subjects Illustrated in the Two Volumes Published.

VOL. I.

BORTHWICK CASTLE, EDINBURGH.
Two Plates.

CAMBUSKENNETH TOWER, STIRLING.

CORSTORPHINE CHURCH, EDINBURGH.

CRAIGMILLAR CASTLE, EDINBURGH.
Two Plates.

CRICHTON CASTLE, EDINBURGH.
Three Plates.

CRICHTON CHURCH, EDINBURGH.

DALMENY CHURCH, LINLITHGOW.
Three Plates.

DUNFERMLINE ABBEY, FIFE.
Four Plates and Two Vignettes.

GLASGOW CATHEDRAL, LANARK.
Four Plates and Two Vignettes.

HADDINGTON CHURCH, HADDINGTON.
Two Plates and Vignette.

HERIOT'S HOSPITAL, EDINBURGH.
Five Plates and Vignette.

HOLYROOD PALACE, EDINBURGH.
Four Plates and Two Vignettes.

KIRKWALL CATHEDRAL, ORKNEY.
Six Plates and Vignette.

KIRKWALL, EARL'S PALACE.

LINLITHGOW CHURCH.
Two Plates and Vignette.

LINLITHGOW PALACE.
Four Plates and Vignette.

MORAY HOUSE, EDINBURGH.

NOLTLAND CASTLE, WESTRAY, ORKNEY

PARLIAMENT HOUSE, EDINBURGH.

ST GILES CATHEDRAL, EDINBURGH.
Three Plates and Vignette.

ST MARGARET'S WELL, EDINBURGH.

STIRLING CASTLE.
Three Plates and Vignette.

STIRLING CHURCH. The Chancel.

TRINITY COLLEGE CHURCH, EDINBURGH.
Two Plates and Vignette.

WINTOUN HOUSE, HADDINGTON.
Three Plates and Vignette.

VOL. II.

ABERBROTHOCK ABBEY, FORFAR.
Three Plates and Vignette.

CAERLAVEROC CASTLE, DUMFRIES.
Three Plates and Two Vignettes.

CASTLE HUNTLY, PERTH.

CHURCH TOWER, DUNDEE.

CRAIGSTONE CASTLE, ABERDEEN.

CRATHES CASTLE, KINCARDINE.
Three Plates.

CROSSRAGUEL ABBEY, AYR.
Four Plates and Vignette.

DIRLETON CASTLE, HADDINGTON.
Two Plates and Vignette.

DOUNE CASTLE, PERTH.
Two Plates and Vignette.

DUNBLANE CATHEDRAL, PERTH.
Four Plates and Vignette.

DUNFERMLINE ABBEY, FIFE.

FYVIE CASTLE, ABERDEEN.
Three Plates and Vignette.

GLAMMIS CASTLE, FORFAR.
Two Plates.

GLASGOW CATHEDRAL, LANARK.
Three Plates.

GLASGOW UNIVERSITY, LANARK.
Three Plates and Vignette.

HOLYROOD PALACE, EDINBURGH.

KILWINNING ABBEY, AYR.

LINCLUDEN COLLEGE, DUMFRIES.
Two Plates.

NEWARK CASTLE, RENFREW.
Two Plates and Vignette.

PAISLEY ABBEY, RENFREW.
Four Plates and Vignette.

ROUND TOWER & CHURCH, BRECHIN.

RUTHVEN CASTLE, (HUNTINGTOWER,) PERTH.

SETON CHAPEL, HADDINGTON.
Two Plates.

ST ANDREWS, FIFE.
Three Plates and Vignette.

ST MONANCE CHURCH, FIFE.
Two Plates.

TANTALLON CASTLE, HADDINGTON.
Three Plates and Vignette.

TOLQUHON CASTLE, ABERDEEN.

In Imperial Folio, half-bound Morocco, Price £10, 10s.

THE PHYSICAL ATLAS.

A SERIES OF MAPS AND ILLUSTRATIONS OF THE GEOGRAPHICAL DISTRIBUTION OF NATURAL PHENOMENA.

EMBRACING

I. GEOLOGY. **III. METEOROLOGY.**
II. HYDROGRAPHY. **IV. NATURAL HISTORY.**

BY

ALEXANDER KEITH JOHNSTON, F.R.G.S. F.G.S.
Geographer at Edinburgh to Her Majesty.

The FOUR DIVISIONS are sold separately—

I. GEOLOGY,	10 Maps and Letterpress, hf.-bd. mor.			£4	14	6
II. HYDROGRAPHY,	6	—	—	2	8	6
III. METEOROLOGY,	5	—	—	1	17	6
IV. NATURAL HISTORY,	9	—	—	4	5	6

For the convenience of Mariners, a Division has been made up, containing the Ocean Currents, Winds, and Tides,—5 Maps, and Letterpress, price £1, 17s. 6d. This division of the Work has received the approbation of the Lords of the Admiralty, and has been ordered by them for use in the Royal Naval College, Portsmouth.

The Plates are also sold in separate Subjects, with Descriptions, a List of which, with Prices, may be had on application to the Publishers.

Blackwood's Magazine.

"To the scholar, to the student, and to the already large, yet daily increasing multitude of inquirers who cultivate natural science, the *Physical Atlas* is a treasure of incalculable value. It brings before the mind's eye, in one grand panoramic view, and in a form clear, definite, and easily comprehensible, all the facts at present known relative to the great subjects of which it treats, and may be regarded as a lucid epitome of a thousand scattered volumes, more or less intrinsically valuable, of which it contains the heart and substance."

North British Review.

"By devoting a single hour to the contemplation of our globe in the diorama of a Physical Atlas, the student will witness the grandeur of the tenement in which he dwells, and will not fail to appreciate the beautiful conception of Humboldt, when he speaks of 'the life of the earth.'"

New York Literary World.

"It is a gigantic monument of the genius of science of the present day."

Quarterly Review.

"This very conviction of its value would lead us to urge upon Mr Johnston the expediency of some reduced form of his great Atlas, which might render it more accessible to common readers. . . We know of no work of which the methods are so well fitted for the instruction of those who come ignorantly to the subject."

From the New Edition of Mrs Somerville's **Physical Geography.**

"The author avails herself, with much pleasure, of an opportunity of expressing her admiration of the accuracy, extent, and execution of Mr Keith Johnston's *Physical Atlas*, and of the valuable information contained in the letterpress which accompanies it, which has afforded her the greatest assistance. It was the author's wish, and her publisher's intention, that the present edition shoud be accompanied by a series of maps to illustrate the more important questions of Physical Geography treated of in it; but Mr A. Keith Johnston having announced the publication of a new edition of his *Physical Atlas*, in a reduced size at a low price—the first two numbers of which have already appeared—the project was relinquished, in the belief that Mr A. K. Johnston's smaller Atlas will furnish suitable illustrations to this work."

In 3 vols., post 8vo, price 31s. 6d.

THE CAXTONS:

A Family Picture.

BY

SIR EDWARD BULWER LYTTON, BART.

Opinions of the Press.

"The most brilliant and the most beautiful of all the effusions of Sir Bulwer Lytton's pen of fascination."—*The Sun.*

"One of those graceful family groups in which all the component parts are in perfect harmony, and all the accessories are wrought out with a skill at once the most marvellous, and apparently the most unpremeditated."—*Morning Herald.*

"One of the best, as it is the most matured, of Sir E. Bulwer Lytton's productions."—*Observer.*

"There are portions of the work equal to anything in the whole range of British fiction. . . . . It is a book that it does one good to read. . . . . An invigorating, a bracing book."—*Atlas.*

"And a beautiful picture it is, too; the portraits striking, yet characteristic; the colouring exquisitely tasteful, yet true to nature."—*New Monthly Magazine.*

"It is his best production. . . . . A book to be read, to be noted, and to be admired."—*Sunday Times.*

"The book is as instructive as it is delightful, and we confidently claim for it a wide and lasting success."—*Examiner.*

"As a work of art, we think it exhibits an advance on all his former productions. . . . . A charming novel, and closes with one of the most eloquent and touching scenes of the peace and sanctity of home we ever met with."—*Britannia.*

"He has assumed the age to be advancing, and shows how he must advance with it or lag behind."—*Literary Gazette.*

"These are true and healthy words, rising from some of the deeper wells of man's nature, and the idea is ably and interestingly developed."—*Guardian.*

"In the book before us, Sir E. Lytton presents himself in his most becoming attitude. . . . . Thus, we repeat, we prefer 'The Caxtons' to most of Sir Bulwer Lytton's recent novels."—*Athenæum.*

"The general voice seems to proclaim it the cleverest of his novels."—*Evening Post, (New York.)*

"Eminently readable and pleasant in itself, as well as a curious study of the author's mind in its present development."—*Literary World, (New York.)*

"It is admirably written, and will remind the reader of 'Tristram Shandy,' though infinitely superior to that work. . . . Bulwer's genius seems to widen and ripen with time."—*Saturday Evening Post, (Philadelphia.)*

"Displaying on every page great learning, exquisite humour, deep insight into human nature, fine eloquence—and, indeed, nearly all those characteristics which make Bulwer the first novelist and most brilliant author of the age."—*The World as it Moves, (U. S.)*

THE COURSE OF TIME. A Poem, in Ten Books. By ROBERT POLLOK, M.A. A New Edition, (being the Nineteenth,) with Portrait, engraved by Robinson. In small 8vo, 7s. 6d., neatly bound in cloth.

POEMS BY THE LADY FLORA HASTINGS. With a Portrait. Second Edition, foolscap 8vo, price 7s. 6d.

"All lovers of that purer poetry which catches half its grace from heaven, will seek for records of its pious beauty upon the gentle pages of this graceful book. We have but glanced at the poems, and gathered only snatches of the beauties which we are prepared to meet on deeper and closer perusal, and of which our readers shall receive their share."—*Morning Post.*

SOLITARY HOURS. By MRS SOUTHEY. In foolscap 8vo. A New Edition. Price 5s.

"Those sweet poems in the little volume of *Solitary Hours*, which for truth and depth of feeling, and for tenderness and holiness of thought, are among the most beautiful that have been produced in this generation."—*Quarterly Review.*

By the same Author,

THE BIRTHDAY AND OTHER POEMS. In foolscap 8vo, price 7s.

"We do not remember any recent author whose poetry is so unmixedly native; and this English complexion constitutes one of its characteristic charms. No purer models of our genuine home feeling and language could be placed in a young foreigner's hands than Mrs Southey's works. Moreover, her versification, especially in her two later volumes, is not only generally correct, but, in several instances, of very great beauty and perfection. In her latest poem, 'The Birthday,' she has attained to a still higher excellence of style."—*Quarterly Review.*

DOMESTIC VERSES. By DELTA. In One Volume foolscap 8vo, price 5s. bound in cloth.

"The poems refer chiefly to the deaths of three beloved children, &c. &c. The sad and solemn beauty of several of them, indeed, speaks with even painful force to the heart; the very form of verse adopted in some, as for example in the case of the 'Ode to Casa Wappy,' is so mournfully attuned, that the production cannot be read without tears. This little work, altogether, will be felt as a rich boon and treat to the feeling heart."—*Scotsman.*

THE LEGEND OF GENEVIEVE. With other Tales and Poems. By DELTA. Post 8vo, price 9s.

LEGENDS, LYRICS, AND OTHER POEMS. By B. SIMMONS. In foolscap 8vo, price 7s. 6d. cloth.

THE RECREATIONS OF CHRISTOPHER NORTH.
In Three Volumes, Post Octavo, price £1, 11s. 6d.

"Welcome, right welcome, Christopher North; we cordially greet thee in thy new dress, thou genial and hearty old man, whose 'Ambrosian nights' have so often in imagination transported us from solitude to the social circle, and whose vivid pictures of flood and fell, of loch and glen, have carried us in thought from the smoke, din, and pent-up opulence of London, to the rushing stream, or tranquil tarn, or those mountain ranges," &c.—*Times.*

By the same Author,

LIGHTS AND SHADOWS OF SCOTTISH LIFE.
Price 3s. cloth.

"What child will not hang over the Tales of the Covenanters in Lights and Shadows of Scottish Life? . . . We have already said a word or two on this delightful volume—the work of one of the most amiable of contemporary minds—a genius which shines with equal felicity in the tender and humorous."—*Quarterly Review.*

THE TRIALS OF MARGARET LYNDSAY. Price 3s. cloth.

THE FORESTERS. Price 3s. cloth.

PROFESSOR WILSON'S POEMS, containing the Isle of Palms, City of the Plague, and other Poems. In two volumes, post 8vo, 21s.

THE ANNALS OF THE PARISH, and AYRSHIRE LEGATEES. By John Galt; with Memoir of the Author, by Delta. Foolscap 8vo, price 6s.

SIR ANDREW WYLIE OF THAT ILK. By John Galt. Foolscap 8vo, price 6s.

THE PROVOST, and OTHER TALES. By John Galt. Foolscap 8vo, price 6s.

THE ENTAIL. By John Galt. Foolscap 8vo, price 6s.

THE POETICAL WORKS OF THOMAS AIRD. In 8vo. Price 5s. cloth.

AN INTRODUCTION TO METEOROLOGY. A Systematic Treatise, wherein the Laws of that important branch of Natural Science are explained by numerous interesting facts, methodically arranged and familiarly described. By DAVID P. THOMSON, M.D. In 8vo, with numerous Illustrations, price 12s. 6d.

"A very complete account of all the atmospheric phenomena yet discovered. It is also a complete treatise on the subject, including all the latest discoveries, inventions, and improvements. It is a great storehouse of facts scientifically and carefully arranged. The style of the work, too, is graceful. It has the further merit of being deeply imbued, like many, and even most, of the scientific works of the present day, with that deep reverence for the Author of Nature, which science was accused, half a century ago, of tending to weaken or destroy."—*The Economist.*

"The manner in which the subject is handled by its learned author, not only introduces order and perspicuity into what has hitherto been considered as the rightful domain, if not of blind chance, at least of unaccountable confusion, but it places the scientific facts and reasonings connected with it within the comprehension of any intelligent person who may wish to inform himself on this important and interesting branch of natural science."—*John Bull.*

A TREATISE ON LAND SURVEYING. By JOHN AINSLIE. A New and Enlarged Edition, embracing Railway, Military, Marine, and Geodetical Surveying, by WILLIAM GALBRAITH, M.A., F.R.A.S. In demy 8vo, price 21s., with an Atlas of Thirty-two Engravings on Steel, by W. & A. K. JOHNSTON, and numerous Illustrations Engraved on Wood, by R. H. BRANSTON.

SIR HENRY STEWART'S PLANTER'S GUIDE. A New Edition, being the Third, enlarged, with the Author's last Additions and Corrections; to which is prefixed a Memoir of the Author, and an Engraving from a very fine Portrait by SIR HENRY RAEBURN. In 8vo, price 21s., cloth.

"His new and improved methods will remain a lasting monument of the zeal, industry, and genius that introduced them. Wherever ornament makes any part of the object of the cultivator, the *Planter's Guide* will be found to be his best director; pointing out, as it does, the means of executing with success the designs that taste may have conceived for the embellishment of the landscape. It teaches not merely the art of planting, but the principles upon which the art is founded; and supplies us not merely with rules but with reasons."—*Edinburgh Review.*

THE CHEMISTRY OF VEGETABLE AND ANIMAL PHYSIOLOGY. By Dr G. J. MULDER, Professor of Chemistry in the University of Utrecht. Translated from the Dutch by Dr P. F. H. FROMBERG, First Assistant in the Laboratory of the Agricultural Chemistry Association of Scotland, with an Introduction and Notes, by JAMES F. W. JOHNSTON, F.R.SS. L. & E. In 8vo, with Twenty-two Plates Coloured and Plain, price 30s.

A MANUAL OF PRACTICAL DRAINING. By HENRY STEPHENS, Esq., F.R.S.E., Author of "The Book of the Farm." Third Edition, price 5s. With Sixty-three Engravings on Wood.

ELKINGTON'S SYSTEM OF DRAINING. A Systematic Treatise on the Theory and Practice of Draining Land, adapted to the various Situations and Soils of England and Scotland, as drawn up by appointment of the Board of Agriculture, from the communications of Joseph Elkington. To which is added, a Treatise on Embankments and the Formation of Artificial Pieces of Water. By JOHN JOHNSTONE, Land-Surveyor. A New Edition, lately published, illustrated by numerous Plans and Sections. 4to, price 10s. 6d.

THE PRACTICAL IRRIGATOR AND DRAINER. By GEORGE STEPHENS, Drainer, Member of the Nerecian and Wermlandska Agricultural Societies in Sweden. In 8vo, illustrated by Copperplates and Woodcuts, price 8s. 6d.

THE FORESTER, being plain and practical Directions for the Planting, Rearing, and General Management of Forest Trees. By JAMES BROWN, Forester, Arniston. Crown 8vo, price 6s.

THE PRACTICAL PLANTER. Containing Directions for the Planting of Waste Land, and Management of Wood, with a New Method of rearing the Oak. By THOMAS CRUICKSHANK, Forrester at Carreston. In 8vo, price 12s.

SEVEN LITHOGRAPHED DESIGNS for the Improvement of Farm Cottages and Steadings. With Descriptions, Specifications, and Estimates; Remarks on the Accommodations required under the Modern System of Husbandry, and the Defects of existing Farm Buildings. By JAMES CUNNINGHAM, Surveyor. Large 8vo, price 6s. 6d.

HIGH FARMING, UNDER LIBERAL COVENANTS,

THE BEST SUBSTITUTE FOR PROTECTION. By JAMES CAIRD, Farmer, Baldoon. Fifth Edition, with Engraved Plan of Farm Buildings. Price 1s., or 1s. 4d. by post.

"I believe it will be of the greatest possible benefit to the agricultural labourer by affording increased employment," &c.—*Speech of the Chancellor of the Exchequer on the state of Ireland*, 2d *July* 1849.

"The publication of such facts at the present time are of great public importance."—*Irish Industrial Journal.*

"We strongly advise our readers to make the whole performance a matter of personal study."—*Agricultural Gazette.*

"His facts are invaluable."—*Journal of Agriculture.*

STABLE ECONOMY: A TREATISE ON THE MANAGEMENT OF HORSES.

By JOHN STEWART, V.S. A New Edition, (being the Fourth,) in foolscap 8vo, with numerous Woodcuts, price 6s. 6d.

"Likely to remain a standard authority on the subjects of which it treats for many years to come. The reader will find in it full instructions on stable economy in all its departments. The construction and ventilation of stables, the character and education of stable men and boys, the nature of their work as regards the grooming, decoration, and general treatment of horses, the habits and vices of horses, and the accidents to which they are liable, the nature, composition, and preparation of their food, the fitness for work, and the best method of keeping them in the best working condition, and the management of diseased and defective horses, are all fully discussed. There is no better book for the instruction of the groom."—*Gardener's Chronicle and Agricultural Gazette.*

"Will always maintain its position as a standard work upon the management of horses."—*Mark Lane Express.*

"The work before us is not one of the many quackery books which are 'made to sell,' but a valuable compendium of the management of the horse in health, and for work, and with a view to keep him in the one, and ready to perform the other. Nor do we know a work on the subject more deserving of confidence and recommendation."—*Farmers' Journal.*

By the same Author,

ADVICE TO PURCHASERS OF HORSES. A New

Edition. Price 2s. 6d. bound in cloth.